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ZUR AXIOMATIK DER LINEAREN ABHÄNGIGKEIT, III (SCHLUSS)

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Zur Axiomatik der linearen Abhängigkeit, III (Schluss).

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§ 1. Einleitung.

In meinen früheren Arbeiten[1] habe ich eine Methode hergestellt und gezeigt, dass sich dieselbe für die Untersuchungen der linearen Abhängigkeit im projektiven Raumes mit Erfolg verwenden lässt. Die betrachtete Methode gehört zu einer algebraischen Symbolenrechnung, bei welcher sogar die einzige Relation d. h. "*gelten*" (natürlich auch die Verneinung "*nicht gelten*") für gewisse Reihen der Elementen aufgeprägt wird. Diese Rechnung habe ich deshalb nach G. Thomsen einen *Zyklenkalkül*[2] genannt.

In der vorliegenden Schrift handelt es sich

1. um den vollständigen Aufbau der projektiven Geometrie, indem die am Anfang meiner Arbeit aufgezählten Rechnungsprinzipien[3] als räumliche Axiome eines geometrischen Raumes gedeutet werden, und
2. um einige Anwendungen zum allgemeinen linearen Raum sowie Vergleichungen mit den verwandten Arbeiten von Herren G. Birkhoff und H. Whitney, und
3. um einen Unabhängigkeitsbeweis der dort angenommenen Axiomengruppe.

(1) T. Nakasawa, "*Zur Axiomatik der linearen Abhängigkeit. I*", Science Reports of the Tokyo Bunrika Daigaku, Sec. A, Vol. **2**, No. 43, (235-255); *II*, ibid., Sec. A, Vol. **3**, No. 51, (45-69). Wegen der Bequemlichkeit bezeichnen wir diese zwei Arbeiten bzw. kurz mit A1 und A2.

(2) Das Wort und die Idee des Zyklenkalküls geht wohl zum G. Thomsenschen Buch, "*Grundlagen der Elementargeometrie*", (Leipzig 1933) zurück. Unter Einfluss seiner Idee habe ich meine axiomatische Untersuchung der linearen Abhängigkeit angefangen.

(3) Vgl. S. 236 in A1, sowie S. 46 in A2!

Schreibt man nun für s Punkte $a_1, a_2, \cdots, a_s$ des klassischen n-dimensionalen projektiven Raumes[4] $a_1 \cdots a_s = 0$ (gewöhnlich in kurzen Zeichen $a_1 \cdots a_s$), bzw. $a_1 \cdots a_s \neq 0$, je nachdem sie linear abhängig oder linear unabhängig sind, so gelten bekanntlich die folgenden Relationen[5];

1° $a \neq 0$, aa .

2° $a_1 \cdots a_s \rightarrow a_1 \cdots a_s x$, $(s \geqq 2)$.

3° $a_1 \cdots a_i \cdots a_s \rightarrow a_i \cdots a_1 \cdots a_s$, $(s \geqq i \geqq 2)$.

4° $xa_1 \cdots a_s$, $a_1 \cdots a_s y \rightarrow a_1 \cdots a_s$ oder $xa_1 \cdots a_{s-1} y$, $(s \geqq 1)$.

5° $a_1 \cdots a_s xy \rightarrow Ez$, $a_1 \cdots a_s z$, xyz, $(s \geqq 2)$.

Umgekehrt, wenn man diese fünf Sätze allein als Rechnungsprinzipien eines logischen Kalküls für den Elementen $a_1, a_2, \cdots, a_s, \cdots$ einer abstrakten Menge $\mathfrak{B}$ aufnimmt, dann lassen sich auf Grund der Axiome 1° bis 4° fast alle Eigenschaften der linearen Abhängigkeit herleiten, welche keine Existenzaussage enthalten. Wenn man ferner das letzte Axiom 5° dazu adjungiert, dann lässt sich der *Dualitätssatz* des linearen Raumes

$$\text{Rang}\,(A \frown B) + \text{Rang}\,(A \smile B) = \text{Rang}\,A + \text{Rang}\,B$$ [6]

beweisen, und sodann werden fast alle Sätze des projektiven Raumes beweisbar. Die Einzelheiten darüber habe ich bereits in meiner Arbeiten A1, A2 ausführlich betrachtet.

In der vorliegenden Schrift will ich die Unterschied klar herzustellen versuchen, welche Sätze der projektiven Geometrie aus den Axiomen 1°–5° herleitbar sind und welche nicht. Dafür scheint es mir zweckmässig das betrachtete 1°–5° Axiomensystem mit dem Veblen-Youngschen[7] zu vergleichen, da ich das letztere für eines der vollständigen und vorbildlichen Systeme halte.

(4) Vgl. z. B. Eugenio Bertini, "*Einführung in die projektive Geometrie mehrdimensionaler Räume*", Wien, 1906, (1-23)!

(5) Betreffs der hier benutzten Bezeichnungen vergleiche S. 235 in A1 oder S. 45 in A2!

(6) Satz 29 auf S. 48 in A2.

(7) O. Veblen and J. W. Young, "*Projective geometry, I*", Boston, 1910, (1-30).

§ 2. Die Vergleichung mit dem Veblen, Youngschen System.

Definition: Es sei $a_1, a_2, \cdots, a_n$ n linear unabhängige Elemente d. h. $a_1 \cdots a_n \neq 0$. Die Menge der allen Elementen x von $\mathfrak{B}$ derart, dass $a_1 \cdots a_n x = 0$ sind, nennen wir den von $a_1, a_2, \cdots, a_n$ erzeugten *linearen Raum* in $\mathfrak{B}$ vom Range n, in Zeichen $\mathfrak{R}^n(a_1 \cdots a_n)$, und den Zyklus $a_1 \cdots a_n$ nennen wir die Basis des $\mathfrak{R}^n(a_1 \cdots a_n)$. Insbesondere nennen wir den linearen Raum vom Range 1 bzw. 2 den *Punkt* bzw. die *Gerade*.

Dann bestehen die folgenden Sätze.

(i) Zwei Punkte $\mathfrak{R}(a)$, $\mathfrak{R}(b)$ stimmen dann und nur dann ein, wenn $ab = 0$.

(ii) Drei Punkte $\mathfrak{R}(a)$, $\mathfrak{R}(b)$, $\mathfrak{R}(c)$ liegen dann und nur dann auf einer einzigen Gerade, wenn $abc = 0$.

(iii) Zwei disjunkte Punkte $\mathfrak{R}(a)$, $\mathfrak{R}(b)$ bestimmen eine einzige Gerade $\mathfrak{R}(ab)$.

(iv) Zwei auf einer Gerade $\mathfrak{R}(ab)$ liegende disjunkte Punkte $\mathfrak{R}(x)$, $\mathfrak{R}(y)$ bestimmen dieselbe Gerade, d. h. $\mathfrak{R}(ab) = \mathfrak{R}(xy)$.

Die Beweise derselben finden sich im noch erweiterten Sinne bereits in A1.

(v) Wenn $\mathfrak{R}(a)$, $\mathfrak{R}(b)$, $\mathfrak{R}(c)$ nicht auf einer Gerade liegen, und $\mathfrak{R}(d)$ auf der Gerade $\mathfrak{R}(bc)$ liegt, und $\mathfrak{R}(e)$ auf der Gerade $\mathfrak{R}(ac)$ liegt, und noch $\mathfrak{R}(d) \neq \mathfrak{R}(e)$ ist, so existiert mindestens ein Durchschnittpunkt $\mathfrak{R}(f)$ von $\mathfrak{R}(ab)$ und $\mathfrak{R}(de)$.

Beweis: Nach der Voraussetzung und nach (i), (ii) folgt, dass $abc \neq 0$, $bcd = 0$, $ace = 0$, und $de \neq 0$.

$$\therefore \left.\begin{matrix} abc \neq 0\,, \\ bcd \quad\;\;, \\ ace \end{matrix}\right\} \to \left.\begin{matrix} abc \neq 0\,, \\ abcd\,, \\ abce \end{matrix}\right\} \longrightarrow abde \longrightarrow Ef\,,\quad abf\,,\; def.$$

Da $ab \neq 0$, $de \neq 0$, $abf = 0$, und $def = 0$ sind, so ist der Punkt $\mathfrak{R}(f)$ der Durchschnitt der Geraden $\mathfrak{R}(ab)$ und $\mathfrak{R}(de)$, w. z. b. w.

(vi) Es seien $\mathfrak{R}(a_1 \cdots a_k)$ ein linearer Raum vom Range k und $\mathfrak{R}(a_{k+1})$ ein nicht darin liegender Punkt. So stimmen der linearen Raum $\mathfrak{R}(a_1 \cdots a_{k+1})$ vom Range $k+1$ ein mit der Menge $\sum_x \mathfrak{R}(a_{k+1}x)$, welche aus allen durch Verbindung des festen Punktes $\mathfrak{R}(a_{k+1})$ mit irgendeinem Punkt $\mathfrak{R}(x)$ von $\mathfrak{R}(a_1 \cdots a_k)$ entstehenden Geraden $\mathfrak{R}(a_{k+}x)$ besteht.

Bewes: Sei $\mathfrak{R}(y)$ ein beliebiger in $\sum_x \mathfrak{R}(a_{k+1}x)$ liegender Punkt,

so folgt, $a_1 \cdots a_k x$, $x a_{k+1} y \to^{(8)} a_1 \cdots a_{k+1} y \to \mathfrak{R}(a_1 \cdots a_{k+1}) \ni \mathfrak{R}(y)$.

$\therefore \quad \sum_x \mathfrak{R}(a_{k+1}x) \subseteq \mathfrak{R}(a_1 \cdots a_{k+1})$.

Sei $\mathfrak{R}(y)$ ein beliebiger in $\mathfrak{R}(a_1 \cdots a_{k+1})$ liegender Punkt, so folgt,

$a_1 \cdots a_{k+1} y \to Ex$, $a_1 \cdots a_k x$, $a_{k+1} y x$.

$\therefore \quad Ex$, $\mathfrak{R}(a_1 \cdots a_k) \ni \mathfrak{R}(x)$, $\mathfrak{R}(a_{k+1}x) \ni \mathfrak{R}(y)$.

$\therefore \quad \sum_x \mathfrak{R}(a_{k+1}x) \supset \mathfrak{R}(a_1 \cdots a_{k+1})$.

Durch Vergleichung der beiden ergibt sich sodann

$$\sum_x \mathfrak{R}(a_{k+1}x) = \mathfrak{R}(a_1 \cdots a_{k+1}), \quad \text{w. z. b. w.}$$

(vii) Bezeichnet man drei auf einer Gerade liegende Punkte als eine Klasse von Punkten, so zerfällt $\mathfrak{B}$ in eine Anzahl von Klassen von Elementen(9), die untereinander keine gemeinsame Elemente besitzen Sei $\mathfrak{P}_\nu$ eine solche Klasse von Elementen, so ist $\mathfrak{P}_\nu$ auch ein $\mathfrak{B}_2$-Raum(10) und $\mathfrak{B}$ zerfällt in die direkte Summe von $\mathfrak{P}_1$, $\mathfrak{P}_2$, $\mathfrak{P}_3$, $\cdots$(11). Dann existieren mindestens drei Punkte auf jeder Gerade von $\mathfrak{P}_\nu$(12).

Der wesentliche Inhalt dieses Satzes findet sich bereits in A2, § 5, SS. 63–69.

Das Veblen-Youngsche Axiom ist folgendes(13):

By a projective geometry is meant a set of elements which, for suggestiveness, are called points subject to the following four conditions:

I. If A and B are distinct points, there is one and only one line that contains A and B.

II. If A, B, C are non-collinear points and if a line l contains a point D of the line (BC) and a point E of the line (AC), where D and E are distinct points, then the line l contains a point F of the line (AB).

III. There are at least three points on every line.

IV. A k-space is defined by the following inductive definition. A point is a 1-space. If A_1, A_2, $\cdots$, A_{k+1} are points not all in the same k-space, the set of all points collinear with the point A_{k+1} and any point of the k-space $(A_1 A_2 \cdots A_k)$ is the $(k+1)$-space $(A_1 A_2 \cdots A_{k+1})$. Thus a line is a 2-space, and a plane is a 3-spece, and so on.

(8) Zusatz 2 zum Satz 24 auf S. 252 in A1.

(9) Satz 63 sowie Zusatz auf S. 63 in A2.

(10) Definition VI auf S. 47, sowie Satz 73 auf S. 69 in A2.

(11) Satz 71, Zusatz, Satz 72, und Zusatz 1 auf SS. 67–68 in A2.

(12) $\mathfrak{P}_\nu$ heisst der $\mathfrak{B}$-Raum. Vgl. Definition XII auf S. 63 in A2!

(13) O. Veblen and W. H. Bussy, "*Finite projective geometries*", Trans. Amer. Math. Soc., Vol. **7**, 1906, (241–242).

Durch Vergleichung dieses Axiomensystems mit den oben bewiesenen Sätzen sehen wir offenbar, dass unsere Sätze (iii), (iv) zu I, (v) zu II, und (vi) zu IV inhaltlich entsprechen. Das Axiom III gilt aber nicht immer im $\mathfrak{B}_2$-Raum, da ein n-Simplex[14] sich als ein $\mathfrak{B}_2$-Raum auffassen lässt. Jedoch besteht dasselbe eben im $\mathfrak{P}$-Raum, folglich auch im linearen Primraum[15].

Also nach (vii) kann man folgendermassen behaupten.

Satz 74. *Jeder $\mathfrak{B}_2$-Raum lässt sich bis auf die Anordnung der Faktoren auf die einzige Weise in die direkte Summe von projektiven Räumen zerlegen. Jeder $\mathfrak{P}$-Raum oder jeder lineare Primraum ist ein projektiver Raum.*

Dem obigen Veblen-Youngschen Axiomensystem, welches eine Definition des, sozusagen, *dimensionsfreien* projektiven Raumes ist, wird gewöhnlich das folgende Dimensionsaxiom hinzugefügt.

V. There is a finite upper bound to the dimensions of the spaces. Let n be the upper bound, our set of points is called an n-dimensional projective space.

Dann besteht der folgende Satz.

Satz 75. *Jeder lineare Primraum vom Range n ist ein n-dimensionaler projektiver Raum. Jeder lineare Raum lässt sich bis auf die Anordnung der Faktoren auf die einzige Weise in die endliche direkte Summe von projektiven Räumen von endlichen Dimensionen zerlegen*[16].

§ 3. Anwendungen und verwandte Arbeiten.

1. Die Anwendung zum allgemeinen linearen Raum[17] und Hilbertschen Raum[18].

Die Abelsche Gruppe $\mathfrak{R}$ mit den linksseitigen Operatoren der reellen Zahlen (oder mit dem allgemeinen abstrakten Körper) heisst den allge-

(14) Unter ein n-simplex verstehen wir die Menge von n Elementen, in deren die *Gelten-Relation* folgendermassen definiert ist; d. h., der Zyklus, der mehr als zwei dieselbe Elementen enthält, setzen wir $=0$, sonst $\neq 0$.

(15) Definition VIII auf S. 52, sowie Zusatz 1 zum Satz 72 auf S. 68 in A2.

(16) Satz 62 auf S. 62, sowie Satz 57 auf S. 60 in A2.

(17) Vgl. z.B. S. Banach, "*Théorie des opérations linéaires*, Warszawa, 1932, Kap. II!

(18) D. Hilbert, "*Grundzüge einer allgemeinen Theorie der linearen Integralgleichungen*", 4. Mitteilung, Göttingen Nachrichten, 1906, (SS, 157-227).

meinenlinearen Raum[19]. Es seien nun $x_1, \cdots, x_s$ je s von Null verschiedene Elemente von $\mathfrak{R}$. Wenn es s reelle Zahlen $a_1, \cdots, a_s$ gibt, die nicht sämtlich gleich Null sind, und für die gilt: $a_1x_1 + \cdots + a_sx_s = 0$ (d. h. $x_1, \cdots, x_s$ vektorabhängig !), bezeichnen wir dies mit $x_1 \cdots x_s = 0$, und sonst mit $x_1 \cdots x_s \neq 0$. Dann werden die fünf Axiome des $\mathfrak{B}_2$-Raum offenbar im $\mathfrak{R}$ erfüllt. Folglich ist folgendes zu behaupten:

Die Menge der allen von Null verschiedenen Elemente des allgemeinen linearen Raums ist ein $\mathfrak{B}_2$-Raum in Bezug auf die oben erklärte lineare Abhängigkeit.

Wenn man ferner die Bedingung $\sum_i a_i = 0$ zur obigen Definition der linearen Abhängigkeit hinzufügt (d. h. $x_1, \cdots, x_s$ punktabhängig !), so sind die vier Axiome des $\mathfrak{B}_1$-Raums offenbar im $\mathfrak{R}$ erfüllt. Also kann man behaupten:

Der allgemeine lineare Raum ist ein $\mathfrak{B}_1$-Raum in Bezug auf die solchermasse definierte Abhängigkeit.

Da es bei den beiden Definitionen der linearen Abhängigkeit mindestens drei Punkte auf jeder Gerade gibt, so ist der allgemeine lineare Raum ein $\mathfrak{P}$-Raum. Der Hilbertsche Raum ist bekanntlich ein Sonderfall des allgemeinen linearen Raumes, daher ist unser Zyklenkalkül auch dazu anzuwenden.

2. Die Anwendung zur "*Lattice*"-Theorie[20], *Boolschen* Algebra[21], und *Verbändentheorie*[22].

Wir denken uns ein solches "Lattice C", welches kommutativ, assoziativ, reduktiv[23], und schwach distributiv[24] ist, und noch dem

(19) S. Banach, "*Sur les opérations dans les ensembles abtraits et leur application aux équations integrales*", Fund. Math., **3**, (1922), S. 135.
A. Tychonoff, "*Ein Fixpunktsatz*", Math. Ann., **111**, (1935), S. 767.

(20) G. Birkhoff, "*On the combination of subalgebras*", Proc. of the Cam. Phil. Soc., **29**, 1933, (441-464), sowie "*Applications of lattice algebra*", ibid., **30**, 1934, (115-122).

(21) E. V. Huntington, "*Set of independent postulates for the algebra of logic*", Trans. of the Amer. Math. Soc., Vol. **5**, 1904, (288-290).
G. Bergmann, "*Zur Axiomatik der Elementargeometrie*", Monat. für Math. und. Phys., **36**, 1929, (269-290).

(22) Fritz Klein, "*Zur Theorie der abstrakten Verknüpfungen*", Math. Ann., **105**, 1931, (308-323), sowie *Über einen Zerlegungssatz in der Theorie der abstrakten Verknüpfungen*", Math. Ann., **106**, 1932, (114-130).

(23) d. h. $a \frown (a \smile b) = a \smile (a \frown b) = a$ für beliebige a, b. L4 auf S. 743 in G. Birkhoff, "*Combinatorial relations in projective geometries*", Ann. of Math., Vol. **36**, 1935, (743-748). Wegen der Bequemlichkeit bezeichnen wir diese Arbeit kurz mit "G. Birkhoff C".

(24) d. h. $(a \smile c) \frown \{b \smile (a \frown c)\} = \{(a \smile c) \frown b\} \smile (a \frown c)$ für beliebige a, b, c. L5 auf S. 442 in G. Birkhoff, "*On the structure of abstract algebras*", Proc. of the Cam. Phil. Soc., **31**, 1935, (433-454).

Vielfachenkettensatz[25], genügt[26]. Dies ist nämlich nach G. Birkhoff sogenanntes "*modular Lattice*", *dessen Elemente lauter von endlichen Dimensionen sind*[27]. Die Menge der allen ein-dimensionalen Elemente, nämlich der allen Punkte von C, bezeichnen wir mit L, und s Punkte $a_1, \cdots, a_s$ derselben bezeichnen wir mit $a_1 \cdots a_s \neq 0$ bzw. $a_1 \cdots a_s = 0$, je nachdem, $\dim(a_1 \smile \cdots \smile a_s) = s$ oder $\dim(a_1 \smile \cdots \smile a_s) < s$ ist. So bestehen offenbar die fünf Axiome des $\mathfrak{B}_2$-Raums in L. Daher gilt;

Die Punktmenge von jedem "modular Lattice", das dem Vielfachenkettensatz genügt, ist ein $\mathfrak{B}_2$-Raum von endlichen Dimensionen.

Es sei hier bemerkt, dass in L aus $a_1 \neq a_2$ $a_1 a_2 \neq 0$ folgt, und demnach besteht der Punkt $\mathfrak{R}(a)$ aus einem einzigen Element a. Setzt man nun noch das Gesetz des Komplements[28] in C voraus, so lässt sich jedes n-dimensionale Element a als $a = a_1 \smile \cdots \smile a_n$ bezüglich der n treffenden Punkte $a_1, \cdots, a_n$ darstellen[29], also kann man folgendermassen behaupten;

Die Punktmenge von jedem "complemented modular Lattice", das dem Vielfachenkettensatz genügt, ist ein $\mathfrak{B}_2$-Raum von endlichen Dimensionen, und jedes Element von Lattice entspricht eineindeutig zu einem linearen Raum von $\mathfrak{B}_2$-Raum.

Setzt man das distributive Gesetz $a \frown (b \smile c) = (a \frown b) \smile (a \frown c)$[30] an die Stelle des schwachen distributiven Gesetzes in "complemented modular Lattice", so ergibt sich die Boolsche Algebra; also ist jede Boolsche Algebra, die dem Vielfachenkettensatz genügt, auch selbstverständlich ein $\mathfrak{B}_2$-Raum. Da in der Boolschen Algebra können keine drei Punkte auf einer Gerade liegen, so zerfällt die Boolsche Algebra in die direkte Summe von endlichen Punkten; infolgedessen wird sie endlich. Es ist ohne weiteres einzusehen, dass sich der von Herrn F. Klein betrachtete sog. Verband auch als ein Lattice auffassen lässt.

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(25) d. i. in jeder Reihe der Produkte $a_1, a_1 \frown a_2, a_1 \frown a_2 \frown a_3, \ldots$ irgend zwei Absätze je gleich sind. L_4 auf S. 801 in G. Birkhoff, "*Abstract linear dependence and lattices*", Amer. Journ. of Math., Vol. **57**, 1935, (800–804).

(26) Das Gesetz des Komplements ist hier nicht immer notwendig.

(27) S. 745 in G. Birkhoff C.

(28) Gesetz des Komplements: Für jedes Element a gibt es wenigstens ein Element nämlich "Komplement" a' derart, dass $a \frown a' \frown x = a \frown a'$ und $a \smile a' \smile x = a \smile a'$ für jedes x sind. Vgl. L7 auf S. 743 in G. Birkhoff C!

(29) S. 746 in G. Birkhoff C.

(30) S. 705 in M. H. Stone, "*Postulates for Boolean algebras and generalized Boolean algebras*", Amer. Journ. of Math., Vol. **57**, 1935, (703-732).

3. Die Beziehung zur H. Whitneyschen Matroidentheorie[31].

Es seien M ein $\mathfrak{B}_1$-Raum[32] von endlichen vielen Elementen $e_1, e_2, \cdots, e_n$, und N seine Teilmenge. Sodann bestehen natürlich die folgende Sätze.

R_1 Rang $\mathfrak{N} = 0$[33].

R_2 Rang $(N+e) = $ Rang $N+k$, wo $k=1$ oder 0 ist.

R_3 Rang $(N+e_1) = $ Rang $(N+e_2) = $ Rang N

$\rightarrow$ Rang $(N+e_1+e_2) = $ Rang N.

Umgekehrt legt man diese drei Sätze der abstrakten aus $e_1, e_2, \cdots, e_n$ bestehenden Menge M als Axiome zugrunde, und schreibt man $e_1 \cdots e_n = 0$ bzw. $e_1 \cdots e_n \neq 0$, je nachdem Rang $(e_1 \cdots e_s) < s$ oder Rang $(e_1 \cdots e_s) = s$ ist, so wird M auch ein $\mathfrak{B}_1$-Raum. Diese R_1, R_2, und R_3 sind in der Tat die Axiome des H. Whitneyschen sogenannten Matroid[34], also kann man folgendermassen behaupten;

Jeder endliche $\mathfrak{B}_1$-Raum ist ein Matroid, und umgekehrt.

§ 4. Die Unabhängigkeit des Axiomensystems.

In diesem Paragraphen soll nun ein Axiomensystem, das zum 1°, 5°-Axiom äquivalent und gleichzeitig untereinander unabhängig ist, hergestellt werden. Zuerst sind die folgenden sieben Eigenschaften aus dem 1°, 5°-Axiom leicht herzuleiten.

1* $a \neq 0$.

2* aba.

3* $ac,\ bc \rightarrow ab$.

4* $abc,\ abd \rightarrow ab$ oder bcd.

5* $abcd \rightarrow acbd$.

6* $a_1 \cdots a_s z,\ zb_1b_2 \rightarrow a_1 \cdots a_s b_1 b_2,\ s \geq 1$.

7* $a_1 \cdots a_s b_1 b_2 \rightarrow Ez,\ a_1 \cdots a_s z,\ zb_1b_2,\ s \geq 1$.

(31) H. Whitney, "*On the abstract properties of linear dependence*", Amer. Journ. of Math., Vol. **57**, 1935, (509-533).

S. Maclane, "*Some interpretations of abstract linear dependence in terms of projective geometry*", Amer. Journ. of Math., Vol. **58**, 1936, (236-240).

(32) S. 236 in A1.

(33) $\mathfrak{N}$ bedeutet die leere Menge.

(34) S. 510 in der obigen H. Whitneyschen Arbeit.

Um die Äquivalenz der beiden Axiomensysteme zu zeigen, wollen wir behaupten ;

(1) Es gilt aa für jedes a.

Beweis : aaa

az, zaa

az, az, $\rightarrow aa$, w. z. b. w.

(2) $ab \rightarrow ba$.

Beweis : bb, $ab \rightarrow ba$, w. z. b. w.

(3) Es gilt baa für beliebige a, b.

Beweis : aba, aba } $\longrightarrow baa$,

$\downarrow$

ab

ba, $aaa \rightarrow baa$, w. z. b. w.

(4) Es gilt aab für beliebige a, b.

Beweis : baa, bab } $\longrightarrow aab$,

$\downarrow$

ba

ab, $bab \rightarrow aab$, w. z. b. w.

(5) $abc \rightarrow bac$.

Beweis : aba, abc } $\longrightarrow bac$,

$\downarrow$

ab

ba, $aac \rightarrow bac$, w. z. b. w.

(6) $abc \rightarrow bca$.

Beweis : abc, aba } $\longrightarrow bca$,

$\downarrow$

ab

ba, $aca \rightarrow bca$, w. z. b. w.

(7) $a_1 \cdots a_s \to a_1 \cdots a_s x$ für jedes x, $s \geqq 2$.

Beweis: $a_1 \cdots a_s$

$a_1 \cdots a_s$, $a_s a_s x$

$a_1 \cdots a_s x$, w. z. b. w.

(8) $a_1 \cdots a_m z$, $zb_1 \cdots b_n \to a_1 \cdots a_m b_1 \cdots b_n$, $m \geqq 1$, $n \geqq 2$.

Beweis: (Vollständige Induktion in Bezug auf n)

$a_1 \cdots a_m z$, $zb_1 \cdots b_n$

$a_1 \cdots a_m z$, $zb_1 \cdots b_{n-2} z_1$, $z_1 b_{n-1} b_n$

$a_1 \cdots a_m b_1 \cdots b_{n-2} z_1$, $z_1 b_{n-1} b_n$

$a_1 \cdots a_m b_1 \cdots b_n$, w. z. b. w.

(9) $a_1 \cdots a_m b_1 \cdots b_n \to Ez$, $a_1 \cdots a_m z$, $zb_1 \cdots b_n$, $m \geqq 1$, $n \geqq 2$.

Beweis: (Vollständige Induktion in Bezug auf n)

$a_1 \cdots a_m b_1 \cdots b_n$

$a_1 \cdots a_m b_1 \cdots b_{n-2} z_1$, $z_1 b_{n-1} b_n$

$a_1 \cdots a_m z$, $zb_1 \cdots b_{n-2} z_1$, $z_1 b_{n-1} b_n$

$a_1 \cdots a_m z$, $zb_1 \cdots b_n$, w. z. b. w.

(10) $a_1 \cdots a_i \cdots a_s \to \dot{a}_i \cdots a_1 \cdots a_s$, $s = 4$, $4 \geqq i \geqq 2$.

Beweis:	$abcd$	$abcd$	$abcd$	
	abz, zcd	$bacd$	$badc$	
	baz, zcd .	$bcad$	$bdac$	
	$bacd$,	$cbad$,	$dbca$,	w. z. b. w.

(11) $a_1 \cdots a_i \cdots a_s \to a_i \cdots a_1 \cdots a_s$, $s \geqq 5$, $s \geqq i \geqq 2$.

Beweis: (Vollständige Induktion in Bezug auf s)

(i) $i \leqq s-2$.

$a_1 \cdots a_i \cdots a_s$

$a_1 \cdots a_i \cdots a_{s-2} z$, $z a_{s-1} a_s$

$a_i \cdots a_1 \cdots a_{s-2} z$, $z a_{s-1} a_s$

$a_i \cdots a_1 \cdots a_s$, w. z. b. w.

(ii) $i = s-1$ (iii) $i = s$

$$a_1 \cdots a_{s-3} a_{s-2} a_{s-1} a_s$$
$$a_{s-2} \cdots a_{s-3} a_1 a_{s-1} a_s$$
$$a_{s-2} \cdots a_{s-3} z\,,\ \ z a_1 a_{s-1} a_s$$

(ii)	(iii)
$a_{s-2} \cdots a_{s-3} z\,,\ \ z a_{s-1} a_1 a_s$	$a_{s-2} \cdots a_{s-3} z\,,\ z a_s a_{s-1} a_1$
$a_{s-2} \cdots a_{s-3} a_{s-1} a_1 a_s$	$a_{s-2} \cdots a_{s-3} a_s a_{s-1} a_1$
$a_{s-1} \cdots a_{s-3} a_{s-2} a_1 a_s\,,$	$a_s \cdots a_{s-3} a_{s-2} a_{s-1} a_1\,,$

w. z. b. w.

(12) $\left.\begin{matrix} abx_1 \cdots x_m\,, \\ aby \end{matrix}\right\} \longrightarrow ab$ od. $bx_1 \cdots x_m y\,,\quad m \geqq 1\,.$

Beweis: $\left.\begin{matrix} abx_1 \cdots x_m\,, \\ aby \end{matrix}\right\}$

$\therefore\ \left.\begin{matrix} abz\,,\ \ zx_1 \cdots x_m\,, \\ aby \end{matrix}\right\}$

$\therefore\ (ab$ od. $bzy),\ zx_1 \cdots x_m$

$\therefore\ ab$ od. $(byz,\ zx_1 \cdots x_m)$

$\therefore\ ab$ od. $bx_1 \cdots x_m y\,,$ w. z. b. w.

(13) $\left.\begin{matrix} a_1 \cdots a_s x_1 \cdots x_m\,, \\ a_1 \cdots a_s y \end{matrix}\right\} \longrightarrow a_1 \cdots a_s$ od. $a_2 \cdots a_s x_1 \cdots x_m y\,,$
$s \geqq 2,\quad m \geqq 1\,.$

Beweis: (Vollständige Induktion in Bezug auf s)

$\left.\begin{matrix} a_1 \cdots a_s x_1 \cdots x_m\,, \\ a_1 \cdots a_s y \end{matrix}\right\}$

$\therefore\ \left.\begin{matrix} a_1 \cdots a_s x_1 \cdots x_m\,, \\ a_1 \cdots a_{s-1} z,\ z a_s y \end{matrix}\right\}$

$\therefore\ (a_1 \cdots a_{s-1}$ od. $a_2 \cdots a_s x_1 \cdots x_m z)\,,\ z a_s y$

$\therefore\ a_1 \cdots a_{s-1}$ od. $(a_2 \cdots a_s x_1 \cdots x_m z\,,\ z a_s y)$

$\therefore\ a_1 \cdots a_{s-1}$ od. $a_s z$ od. $a_2 \cdots a_s x_1 \cdots x_m y$

$\therefore\ a_1 \cdots a_{s-1}$ od. $(a_1 \cdots a_{s-1} z\,,\ z a_s)$ od. $a_2 \cdots a_s x_1 \cdots x_m y$

$\therefore\ a_1 \cdots a_{s-1}$ od. $a_1 \cdots a_s$ od. $a_2 \cdots a_s x_1 \cdots x_m y$

$\therefore\ a_1 \cdots a_s$ od. $a_2 \cdots a_s x_1 \cdots x_m y\,,$ w. z. b. w.

Folglich gilt ;

Satz 76. *Das 1^*, 7^*-Axiom und 1°, 5°-Axiom sind miteinander äquivalent.*

Wir wollen nun die Unabhängigkeit des 1^*, 7^*-Axiomensystems zeigen.

(1) 1^* ist von übrigen Axiomen unabhängig.

Beweis: Dafür brauchen wir uns nur eine aus einzigen Element bestehende Menge zu denken, indem wir allen Zyklen als " $=0$ " setzen.

(2) 2^* ist von übrigen unabhängig.

Beweis: Dafür brauchen wir uns nur eine aus einzigen Elemente bestehende Menge zu denken, indem wir dann allen Zyklen als " $\neq 0$ " setzen.

(3) 3^* ist von übrigen unabhängig.

Beweis: Wir denken uns eine aus zwei Elementen a, b bestehende Menge, und deuten dann die Abhängigkeit der Zyklen folgendermassen:

Anzahl der Elemente des Zyklus	1	2	3 $\leqq$
Festsetzung der Abhängigkeit des Zyklus	$\neq 0$	$ab \neq 0$ sonst, $=0$	$=0$

(4) 4^* ist von übrigen unabhängig.

Beweis: Um ein konkretes Model zu geben denken wir uns eine aus drei Elementen a, b, c bestehende Menge, und definieren dann die Abhängigkeit der Zyklen durch die folgende Festsetzung:

Anzahl der Elemente des Zyklus	1	2	3	4 $\leqq$
Festsetzung der Abhängigkeit des Zyklus	$\neq 0$	$A \neq 0$ $B=0$	$abc \neq 0$ sonst, $=0$	$=0$

wobei:

A: der aus lauter verschiedenen Elementen bestehende Zyklus und

B: der mindestens ein Paar von denselben Elementen enthaltende Zyklus.

(5) 5* ist von übrigen unabhängig.

Beweis: Als ein konkretes Model denken wir uns eine aus fünf Elementen a, b, c, d, e bestehende Menge, und definieren die Abhängigkeit der Zyklen durch folgende Festsetzung:

Anzahl der Elemente des Zyklus	1	2	3	4	5 $\leqq$
Festsetzung der Abhängigkeit des Zyklus	$\neq 0$	$A \neq 0$ $B = 0$	$B = 0$ $(abe) = 0$ $(cde) = 0$ sonst, $\neq 0$	$B = 0$ $(e) = 0$ $((ab)(cd)) = 0$ sonst, $\neq 0$	$= 0$

wobei:

A: der aus lauter verschiedenen Elementen bestehende Zyklus,

B: der mindestens ein Paar von denselben Elementen enthaltende Zyklus,

(abe): der in beliebiger Reihenfolge aus a, b, e bestehende Zyklus, und dasselbe gilt für (cde),

(e): der wenigstens einmal e enthaltende Zyklus, und

$((ab)(cd))$: einer der $abcd$, $bacd$, $abdc$, und $badc$ ist.

(6) 6_1^* ist von übrigen unabhängig.

Beweis: Als ein Model denken wir uns eine aus drei Elementen a, b, c bestehende Menge, indem wir die Abhängigkeit der Zyklen folgendermassen festsetzen:

Anzahl der Elemente des Zyklus	1	2	3	4 $\leqq$
Festsetzung der Abhängigkeit des Zyklus	$\neq 0$	$= 0$	$aab \neq 0$ sonst, $= 0$	$= 0$

(7) 6_s^*, ($s \geqq 2$) ist von übrigen unabhängig.

Beweis: Wir betrachten eine aus einem einzigen Element bestehende Menge, inwelcher die Abhängigkeit der Zyklen folgendermassen definiert ist:

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SECTION A

No. 56

ALLGEMEINE RESULTANTENTHEORIE BEI FORMEN HOMOGENER VARIABLENREIHEN

Von

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Allgemeine Resultantentheorie bei Formen homogener Variablenreihen.

Von Tikara TÔYA.

(Eingegangen am 10. 10. 1936.)

In der letzten Arbeit[1] habe ich die "Resultantentheorie bei Formen in zwei Variablenreihen" entwickelt. Es soll im folgenden die Theorie auf mehrere Variablenreihen ausgedehnt werden. Dabei setze ich die Theorie bei einer Variablenreihe, insbesondere die folgenden beiden Sätze voraus[2].

Satz A. Für ein System von Formen

(1) $$F_1, F_2, \ldots\ldots, F_r$$

in einer homogenen Variablenreihe

(2) $$x_1, x_2, \ldots\ldots, x_n$$

mit unbestimmten Koeffizienten gibt es ein System von Polynomen

(3) $$\Delta_1, \Delta_2, \ldots\ldots, \Delta_\lambda$$

in den Koeffizienten von (1) allein derart, dass jedes Δ_i homogen in den Koeffizienten jeder einzelnen Form F_k ist und dass die Formen (1) für spezielle Werte der Koeffizienten dann und nur dann eine nichttriviale gemeinsame Nullstelle haben, wenn alle Polynome (3) gleichzeitig verschwinden.

Wir nennen (3) ein *Resultantensystem* von (1), und das von (3) erzeugte Polynomideal das *Trägheitsideal* von (1), und dessen Elementen die entsprechenden *Trägheitsformen.*

(1) Science Reports of the Tokyo Bunrika Daigaku Section A, Vol. 3, No. 54.
(2) Vgl. B. L. van der Waerden, Moderne Algebra II, §§ 76–78.

Satz B. Ein Polynom T in den Koeffizienten der Formen F_i allein ist dann und nur dann eine Trägheitsform derselben Formen, wenn es für jedes ν ein t mit der Eigenschaft

$$x_\nu^t T \equiv 0 \qquad (F_1, F_2, \ldots, F_r)$$

gibt.

§ 1.

Es seien

$$(4) \qquad f_1, f_2, \ldots, f_r$$

r Formen in m homogenen Variablenreihen

$$(5_i) \qquad x_{i1}, x_{i2}, \ldots, x_{in_i}$$
$$(i = 1, 2, \ldots, m)$$

mit unbestimmten Koeffizienten; f_k haben den Grad a_{ki} in den Variablen (5_i), wobei wir den Fall $a_{k1} = a_{k2} = \cdots = a_{km} = 0$ ausschliessen. Wir fragen nach den Bedingungen für die Existenz einer gemeinsamen in jeder einzelnen Variablenreihe nichttrivialen Nullstelle der Formen f_i bei speziellen Werten der Koeffizienten.

Die notwendige und hinreichende Bedingung für die Existenz einer gemeinsamen nichttrivialen Nullstelle von (4), betrachtet als Funktionen von (5_1), ist, nach Satz A, dass das Trägheitsideal derselben Formen in bezug auf (5_1) Nullideal ist.

Es sei

$$(6_1) \qquad J_1^{(1)}, J_2^{(1)}, \ldots, J_{r_1}^{(1)}$$

ein Resultantensystem der Formen f_i in bezug auf die Variablenreihe (5_1), so sieht man nach Satz A leicht ein, dass jedes $J_k^{(1)}$ homogen in den Koeffizienten jeder einzelnen Form f_i sowie in den Variablen jeder einzelnen Reihe (5_i) $(i = 2, 3, \cdots, m)$ ist.

Die notwendige und hinreichende Bedingung für die Existenz einer gemeinsamen nichttrivialen Nullstelle von (6_1), betrachtet als Funktionen von (5_2), ist ebenfalls, dass das Trägheitsideal derselben Polynomen in bezug auf (5_2) Nullideal ist.

Also ist diese Bedingung notwendig und hinreichend für die Existenz einer gemeinsamen nichttrivialen Nullstelle der Formen f_i in den beiden Variablenreihen (5_1) und (5_2).

Es sei

$$(6_2) \qquad J_1^{(2)}, \; J_2^{(2)}, \; \ldots\ldots, \; J_{r_2}^{(2)}$$

ein Resultantensystem der Formen (6_1) in bezug auf die Variablenreihe (5_2), so ist jedes $J_k^{(2)}$ homogen in den Koeffizienten jeder einzelnen Form $J_k^{(1)}$ sowie in den Variablen jeder einzelnen Reihe (5_i) ($i = 3, 4, \cdots, m$).

So fortfahrend erhält man schliesslich ein Resultantensystem

$$(6_m) \qquad J_1^{(m)}, \; J_2^{(m)}, \; \ldots\ldots, \; J_{r_m}^{(m)},$$

wobei jedes Polynom $J_k^{(m)}(k = 1, 2, \cdots, r_m)$ homogen in den Koeffizienten jeder einzelnen Form f_i ist; und die letzteren Formen haben dann und nur dann eine nichttriviale gemeinsame Nullstelle in bezug auf sämtliche Variablenreihen, wenn alle Polynome (6_m) gleichzeitig verschwinden.

Das Polynomideal, erzeugt von den $J_k^{(m)}(k = 1, 2, \cdots, r_m)$, bezeichnen wir mit $\mathfrak{T}$.

Definition. Wir nennen das Ideal $\mathfrak{T}$ das Trägheitsideal der Formen $f_1, \cdots, f_r$ in bezug auf die Variablenreihen (5_i) ($i = 1, 2, \cdots, m$), und dessen Elementen die entsprechenden Trägheitsformen.

Ein Polynom T in den Koeffizienten der Formen f_i allein gehört, wie man nach Satz B leicht ersieht, dann und nur dann dem Ideal $\mathfrak{T}$, wenn zu jedem $(\nu_1, \nu_2, \cdots, \nu_m)$ ein $(t_1, t_2, \cdots, t_m)$ existiert, so dass

$$x_{1\nu_1}^{t_1} x_{2\nu_2}^{t_2} \ldots\ldots x_{m\nu_m}^{t_m} T \equiv 0 \qquad (f_1, f_2, \ldots\ldots, f_r)$$

ausfällt. Somit ergibt sich der

Satz 1. Die notwendige und hinreichende Bedingung dafür, dass $f_1, \cdots, f_r$ eine gemeinsame nichttriviale Nullstelle in den Variablenreihen (5_i) ($i = 1, 2, \cdots, m$) haben, besteht darin, dass das Trägheitsideal $\mathfrak{T}$ Nullideal ist. Dabei besteht $\mathfrak{T}$ aus allen denjenigen Polynomen T in den Koeffizienten der Formen f_i allein, für die (7) gilt.

Wir setzen nun

$$
(4') \quad \begin{cases} f_1 = a_1 x_{11}^{\alpha_{11}} x_{21}^{\alpha_{12}} \ldots\ldots x_{m1}^{\alpha_{1m}} + \ldots\ldots + a_\omega x_{1n_1}^{\alpha_{11}} x_{2n_2}^{\alpha_{12}} \ldots\ldots x_{mn_m}^{\alpha_{1m}} \\ \qquad = f_1^* + a_\omega x_{1n_1}^{\alpha_{11}} x_{2n_2}^{\alpha_{12}} \ldots x_{mn_m}^{\alpha_{1m}}, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ f_r = e_1 x_{11}^{\alpha_{r1}} x_{21}^{\alpha_{r2}} \ldots\ldots x_{m1}^{\alpha_{rm}} + \ldots\ldots + e_\omega x_{1n_1}^{\alpha_{r1}} x_{2n_2}^{\alpha_{r2}} \ldots\ldots x_{mn_m}^{\alpha_{rm}} \\ \qquad = f_r^* + e_\omega x_{1n_1}^{\alpha_{r1}} x_{2n_2}^{\alpha_{r2}} \ldots\ldots x_{mn_m}^{\alpha_{rm}}. \end{cases}
$$

Ist

$$
T(a_1, \ldots\ldots, a_\omega; \ldots\ldots; e_1, \ldots\ldots, e_\omega)
$$

eine Trägheitsform dieser Formen, so folgt aus (7) und (4′)

$$
T\left(a_1, \ldots\ldots, -\frac{f_1^*}{x_{1n_1}^{\alpha_{11}} \ldots\ldots x_{mn_m}^{\alpha_{1m}}}; \ldots\ldots; e_1, \ldots\ldots, -\frac{f_r^*}{x_{1n_1}^{\alpha_{r1}} \ldots\ldots x_{mn_m}^{\alpha_{rm}}}\right) = 0,
$$

mithin, $x_{1n_1} = \cdots = x_{mn_m} = 1$ eingesetzt,

$$
T\left(a_1, \ldots\ldots, -[f_1^*]; \ldots\ldots; e_1, \ldots\ldots, -[f_r^*]\right) = 0.
$$

Daraus folgt der

Satz 2. Wenn $f_1, \cdots, f_r$ eine von Null verschiedene Trägheitsform haben, so existiert eine algebraische Abhängigkeit zwischen den Formen

$$
[f_1^*], \ldots\ldots, [f_r^*].
$$

Diese Abhängigkeit bleibt bei jeder Spezialisierung der Koeffizienten von $[f_i^*]$ bestehen.

§ 2.

Wir fragen in welchen Fällen das Trägheitsideal der allgemeinen Formen f_i Nullideal ist.

Es seien

$$
(8_k) \qquad x_{i1}^{\alpha_{ki}}, \; x_{i2}^{\alpha_{ki}}, \; \ldots\ldots, \; x_{in_i}^{\alpha_{ki}}
$$

$$
(i = 1, 2, \ldots\ldots, m)
$$

m Reihen von Variablenpotenzen, wobei die m Exponenten α_{k1}, α_{k2}, $\cdots$, α_{km} nicht zugleich verschwinden.

Es sei g_k eine in jeder Reihe von (8_k) lineare homogene Form mit unbestimmten Koeffizienten.

Wir betrachten l Formen

$$(9) \qquad g_k \quad \text{für} \quad k = 1, 2, \ldots, l,$$

wobei $l = \Sigma n_i - m + 1$ ist, und beweisen den folgenden

Satz 3. Das System (9) hat keine nichttriviale gemeinsame Nullstelle in bezug auf m Variablenreihen (5_i).

Beweis. Es ist klar, dass dieser Satz im Fall $n_1 = n_2 = \cdots = n_m = 1$ gilt. Wir wenden hier den Induktionsschluss nach der Anzahl $\sum_{i=1}^{m} n_i$ der gesamten Variablen an.

Man darf $n_1 \leqq n_i$ für $i = 2, 3, \cdots, m$ voraussetzen.

Hätte nun das System (9) eine nichttriviale gemeinsame Nullstelle, so würde auch das Spezialsystem

$$(10_1) \qquad \begin{cases} \bar{g}_1 = x_{11}^{\alpha_{11}} x_{21}^{\alpha_{12}} \ldots x_{m1}^{\alpha_{1m}}, \\ \bar{g}_2 = x_{12}^{\alpha_{21}} x_{22}^{\alpha_{22}} \ldots x_{m2}^{\alpha_{2m}}, \\ \ldots\ldots\ldots\ldots\ldots \\ \bar{g}_{n_1} = x_{1n_1}^{\alpha_{n_1 1}} x_{2n_1}^{\alpha_{n_1 2}} \ldots x_{mn_1}^{\alpha_{n_1 m}}, \end{cases}$$

$$(10_2) \qquad g_{n_1+1}, \; g_{n_1+2}, \; \ldots, \; g_l$$

eine haben.

Aus (10_1) müssen in einer solchen Nullstelle mindestens n_1 Variablen $x_{i\nu}$ $(i = 1, 2, \cdots, m;\ \nu = 1, 2, \cdots, n_1)$ gleich Null sein. Man setze in (10_2) genau n_1 Variablen davon gleich Null, so erhält man ein neues System:

$$(9') \qquad g_1^{(1)}, \; g_2^{(1)}, \; \ldots, \; g_{l_1}^{(1)} \qquad (l_1 = l - n_1),$$

das offenbar wiederum eine nichttriviale gemeinsame Nullstelle hat.

Dieses System $(9')$ besteht aber aus $l_1 = l - n_1$ Formen, die in bezug auf $\sum_{i=2}^{l} n_i$ übrigbleibende Variablenpotenzen genau dieselbe Gestalt haben

wie g_k, d.h. (9') ist ein System wie (9) mit geringerer Variablenzahl, w.z.b.w.

Satz 4. Im Fall $r \geqq l$ *ist das Trägheitsideal der allgemeinen Formen* $f_1, \cdots, f_r$ *kein Nullideal.*

Beweis. Es ist klar nach Satz 3.

Wir bezeichnen mit $\mathfrak{M}$ die Menge der m ersten natürlichen Zahlen: $1, 2, \cdots, m$, und mit

$$\{1\}, \{2\}, \ldots\ldots, \{m\}, \mathfrak{A}, \mathfrak{B}, \ldots\ldots, \mathfrak{M}$$

die sämtlichen nicht leeren Teilmengen von $\mathfrak{M}$.

Es seien gegeben m nicht negative ganze Zahlen einerseits:

$$l_1, l_2, \ldots\ldots, l_m$$

und solche Zahlen zu jeder Teilmenge von $\mathfrak{M}$ andererseits:

$$\varphi_{\{1\}}, \varphi_{\{2\}}, \ldots\ldots, \varphi_{\{m\}}, \varphi_{\mathfrak{A}}, \varphi_{\mathfrak{B}}, \ldots\ldots, \varphi_{\mathfrak{M}}.$$

Man setze

$$L_{\mathfrak{N}} = \sum_{i \in \mathfrak{N}} l_i \quad \text{und} \quad \Phi_{\mathfrak{N}} = \sum_{\mathfrak{N}' \subseteq \mathfrak{N}} \varphi_{\mathfrak{N}'},$$

wobei $\mathfrak{N}$ eine beliebige Teilmenge von $\mathfrak{M}$ bedeutet.

Dann besteht der

Hilfssatz[3]. *Wenn zu gegebenen Zahlen* l_i *und* $\varphi_{\mathfrak{N}}$ *solche nicht negative ganze Zahlen* $\varphi_{\mathfrak{N}i}(i = 1, 2, \cdots, m)$ *existieren, welche den folgenden Bedingungen genügen:*

$$(12) \qquad \begin{cases} \varphi_{\mathfrak{N}} = \varphi_{\mathfrak{N}1} + \varphi_{\mathfrak{N}2} + \ldots\ldots + \varphi_{\mathfrak{N}m} \\ \varphi_{\mathfrak{N}i} \geqq 0 \quad \text{falls} \quad i \in \mathfrak{N} \\ \qquad = 0 \quad \text{falls} \quad i \notin \mathfrak{N} \end{cases}$$

$$(13) \qquad \varphi_{\{i\}i} + \varphi_{\mathfrak{A}i} + \varphi_{\mathfrak{B}i} + \ldots\ldots + \varphi_{\mathfrak{M}i} \leqq l_i,$$

$$(i = 1, 2, \ldots\ldots, m)$$

(3) Herr T. Nakasawa hat mir einen einfachen Beweis hierfür durch vollständige Induktion nach der Summe $\Sigma\varphi_{\mathfrak{N}}$ mitgeteilt.

dann gelten für alle $\mathfrak{N} \subseteq \mathfrak{M}$ *die Ungleichungen*

$$\Phi_{\mathfrak{N}} \leqq L_{\mathfrak{N}}; \tag{14}$$

und umgekehrt.

Beweis. Erstens folgt die Ungleichung (14) aus (12) und (13) so:

$$\Phi_{\mathfrak{N}} = \sum_{\mathfrak{N}' \subseteq \mathfrak{N}}' \Phi_{\mathfrak{N}'} = \sum_{\mathfrak{N}' \subseteq \mathfrak{N}}' \sum_{i \in \mathfrak{N}'}' \varphi_{\mathfrak{N}'i} = \sum_{i \in \mathfrak{N}}' \sum_{\mathfrak{N}' \subseteq \mathfrak{N}}' \varphi_{\mathfrak{N}'i}$$

$$\leqq \sum_{i \in \mathfrak{N}}' \sum_{\mathfrak{N}' \subseteq \mathfrak{M}}' \varphi_{\mathfrak{N}'i} \leqq \sum_{i \in \mathfrak{N}}' l_i = L_{\mathfrak{N}}.$$

Zweitens seien die Ungleichungen (14) für alle $\mathfrak{N} \subseteq \mathfrak{M}$ erfüllt. Für eine Teilmenge $\{i\}$ mit einem Element sind die $\varphi_{\{i\}j}$ nach (12) unmittelbar bestimmt, nämlich so:

$$\varphi_{\{i\}i} = \varphi_{\{i\}}, \quad \varphi_{\{i\}j} = 0 \qquad (j \neq i).$$

Es sei nun $\mathfrak{H}$ eine Teilmenge von $\mathfrak{M}$ mit mindestens zwei Elementen, für die $\varphi_{\mathfrak{H}} > 0$ ist.

Wir wollen ein Element k aus $\mathfrak{H}$ auswählen so dass, wenn man statt $\varphi_{\{k\}}$ bzw. $\varphi_{\mathfrak{H}}$ in (11) $\varphi'_{\{k\}} = \varphi_{\{k\}}+1$ bzw. $\varphi'_{\mathfrak{H}} = \varphi_{\mathfrak{H}}-1$ ersetzt, die entsprechenden Ungleichungen (14) für das neue System immer noch bestehen.

Ist dies möglich, so kann man durch mehrmalige Anwendungen desselben Verfahrens das System (11) zuletzt in solch ein System verwandeln:

$$\varphi^*_{\{1\}}, \varphi^*_{\{2\}}, \dots, \varphi^*_{\{m\}}; \varphi^*_{\mathfrak{A}}, \varphi^*_{\mathfrak{B}}, \dots, \varphi^*_{\mathfrak{M}}, \tag{11*}$$

wobei $\varphi^*_{\mathfrak{A}} = \varphi^*_{\mathfrak{B}} = \cdots = \varphi^*_{\mathfrak{M}} = 0$ ausfällt, und hierfür entsprechend den Ungleichungen (14)

$$\varphi^*_{\{i\}} \leqq l_i \tag{14*}$$

bestehen.

Bezeichnet man mit $\varphi_{\mathfrak{H}k}$ die Zahl, wievielmal man bis zum Ende des oben erwähnten Verfahrens gebraucht hat, die zur festen Teilmenge $\mathfrak{H}$ gehörige φ-Zahl um eins zu vermindern und zu einer festen Zahl k gehörige φ-Zahl um eins zu vermehren. Dann gilt offenbar

$$\varphi^*_{\{i\}} = \varphi_{\{i\}i} + \varphi_{\mathfrak{A}i} + \varphi_{\mathfrak{B}i} + \dots + \varphi_{\mathfrak{M}i},$$

somit ergibt sich nach (14*) die Ungleichung (13).

Wir haben also nur zu zeigen, dass ein Element k mit der oben genannten Eigenschaft in $\mathfrak{H}$ vorhanden ist.

Für diejenige Teilmenge $\mathfrak{N}$, welche $\mathfrak{H}$ umfasst, bleibt die Ungleichung (14) nach der oben erwähnten Ersetzung bestehen, da in diesem Fall sowohl $\varphi_{\mathfrak{H}}$ als auch $\varphi_{\{k\}}$ in $\Phi_{\mathfrak{N}}$ enthalten sind, und der Wert von $\Phi_{\mathfrak{N}}$ nicht ändert.

Also braucht man nur diejenige Teilmenge $\mathfrak{N}$ von $\mathfrak{M}$ zu betrachten, welche $\mathfrak{H}$ nicht umfasst und ausserdem in der entsprechenden Ungleichung (14) das Gleichheitszeichen gilt. Es bedeuten

$$\mathfrak{N}_1\,,\quad \mathfrak{N}_2\,,\quad \ldots\ldots\,,\quad \mathfrak{N}_\nu$$

alle solche Teilmengen von $\mathfrak{M}$, d.h. $\mathfrak{N}_i \not\geqq \mathfrak{H}$ und $\Phi_{\mathfrak{N}_i} = L_{\mathfrak{N}_i}$ gelten.

Es ist genug zu zeigen, dass die Vereinigungsmenge aller dieser Mengen nicht $\mathfrak{H}$ umfasst, so dass man ein Element k von $\mathfrak{H}$ ausserhalb derselben Vereinigungsmenge auswählen kann.

Wir bezeichnen, für zwei beliebige Teilmengen $\mathfrak{A}$ und $\mathfrak{B}$ von $\mathfrak{M}$, ihre Vereinigungsmenge bzw. Durchschnitt mit $(\mathfrak{A}, \mathfrak{B})$ bzw. $[\mathfrak{A}, \mathfrak{B}]$ und noch die Summe $\Sigma\varphi_{\mathfrak{C}}$, über alle diejenigen Teilmengen $\mathfrak{C}$ von $(\mathfrak{A}, \mathfrak{B})$, die weder in $\mathfrak{A}$ noch in $\mathfrak{B}$ enthalten sind, mit $\Phi_{\mathfrak{A},\,\mathfrak{B}}$, d.h.

$$\Phi_{\mathfrak{A},\,\mathfrak{B}} = \sum \varphi_{\mathfrak{C}}\,.$$

Dann zeigt man ohne Schwierigkeit die beiden folgenden Beziehungen:

$$L_{\mathfrak{A}} + L_{\mathfrak{B}} = L_{(\mathfrak{A},\,\mathfrak{B})} + L_{[\mathfrak{A},\,\mathfrak{B}]}\,,$$

$$\Phi_{\mathfrak{A}} + \Phi_{\mathfrak{B}} + \Phi_{\mathfrak{A},\,\mathfrak{B}} = \Phi_{(\mathfrak{A},\,\mathfrak{B})} + \Phi_{[\mathfrak{A},\,\mathfrak{B}]}\,.$$

Setzt man hierin $\mathfrak{A} = \mathfrak{N}_1$ und $\mathfrak{B} = \mathfrak{N}_2$ ein, so erhält man wegen $\Phi_{\mathfrak{N}_1} = L_{\mathfrak{N}_1}$, $\Phi_{\mathfrak{N}_2} = L_{\mathfrak{N}_2}$, $\Phi_{\mathfrak{N}_1,\,\mathfrak{N}_2} \geqq 0$ und (14) die Gleichungen

$$\Phi_{\mathfrak{N}_1,\,\mathfrak{N}_2} = 0\,,\quad \Phi_{(\mathfrak{N}_1,\,\mathfrak{N}_2)} = L_{(\mathfrak{N}_1,\,\mathfrak{N}_2)}\,,\quad \Phi_{[\mathfrak{N}_1,\,\mathfrak{N}_2]} = L_{[\mathfrak{N}_1,\,\mathfrak{N}_2]}\,.$$

Wenn nun die Menge $(\mathfrak{N}_1, \mathfrak{N}_2)$ die $\mathfrak{H}$ nicht umfasst, so erhält man aus

$$\Phi_{\mathfrak{N}_3} = L_{\mathfrak{N}_3} \quad \text{und} \quad \Phi_{(\mathfrak{N}_1,\,\mathfrak{N}_2)} = L_{(\mathfrak{N}_1,\,\mathfrak{N}_2)}$$

in ähnlicher Weise wie oben

$$\Phi_{(\mathfrak{N}_1, \mathfrak{N}_2), \mathfrak{N}_3} = 0, \quad \Phi_{(\mathfrak{N}_1, \mathfrak{N}_2, \mathfrak{N}_3)} = L_{(\mathfrak{N}_1, \mathfrak{N}_2, \mathfrak{N}_3)} \quad \text{und}$$

$$\Phi_{[\mathfrak{N}_1, \mathfrak{N}_2, \mathfrak{N}_3]} = L_{[\mathfrak{N}_1, \mathfrak{N}_2, \mathfrak{N}_3]},$$

usw.

Wäre nun die Menge $\mathfrak{H}$ zum ersten Mal in $(\mathfrak{N}_1, \ldots, \mathfrak{N}_\nu)$ enthalten, so würde wie oben die Gleichung folgen:

$$\Phi_{(\mathfrak{N}_1, \ldots, \mathfrak{N}_{\nu-1}), \mathfrak{N}_\nu} = 0,$$

während nach $(\mathfrak{N}_1, \ldots, \mathfrak{N}_{\nu-1}) \not\supseteq \mathfrak{H}$, $\mathfrak{N}_\nu \not\supseteq \mathfrak{H}$ und $\varphi_{\mathfrak{H}} > 0$ die Ungleichung

$$\Phi_{(\mathfrak{N}_1, \ldots, \mathfrak{N}_{\nu-1}), \mathfrak{N}_\nu} \neq 0$$

besteht im Gegensatz zu der oberen Gleichung.

Also kann keine Menge $(\mathfrak{N}_1, \ldots, \mathfrak{N}_\nu)$ die $\mathfrak{H}$ umfassen, w. z. b. w.

Es seien

$$(*) \qquad (5_{h_1}), \ (5_{h_2}), \ \ldots, \ (5_{h_\mu})$$

ein beliebiges System von Variablenreihen aus den (5_i); man setze hierfür

$$\lambda = \sum_{i=1}^{\mu} n_{h_i} - \mu + 1.$$

Dann gilt der

Satz 5 (Hauptsatz 1). Die notwendige und hinreichende Bedingung dafür, dass das Trägheitsideal von r allgemeinen Formen

$$(4) \qquad f_1, \ f_2, \ \ldots, \ f_r$$

in m homogenen Variablenreihen

$$(5) \qquad x_{i1}, \ x_{i2}, \ \ldots, \ x_{in_i} \qquad (i = 1, 2, \ldots, m)$$

Nullideal ist, besteht darin, dass für jedes System von Variablenreihen

$$(*) \qquad (5_{h_1}), \ (5_{h_2}), \ \ldots, \ (5_{h_\mu})$$

höchstens $\lambda-1$ Formen aus (4) nur von den Variablen aus dem System (∗) abhängen.

Beweis. Wenn es für irgendein System (*) von Variablenreihen mehr als $\lambda-1$ nur von den Variablen derselben Reihen abhängigen Formen gibt, dann ist nach Satz 4 eine von Null verschiedene Trägheitsform vorhanden, d.h. dass das Trägheitsideal kein Nullideal ist.

Zweitens sei die im Satz erwähnte Bedingung erfüllt.

Wir setzen

$$(15) \qquad n_i - 1 = l_i$$

und bezeichnen din Anzahl der Formen, die nur von den Variablen des Systems (*) abhängen und zwar diese wirklich enthalten, mit $\varphi_{\mathfrak{N}}$, wobei $\mathfrak{N}$ die Menge $\{h_1, \ldots, h_\mu\}$ bedeutet.

Dann erhält man, bei Benutzung der im Hilfssatz eingeführten Bezeichnungen

$$\lambda - 1 = \sum_{i=1}^{\mu} n_{h_i} - \mu = \sum_{i=1}^{\mu}(n_{h_i}-1) = \sum_{i=1}^{\mu} l_{h_i} = \sum_{i\in\mathfrak{N}} l_{h_i} = L_{\mathfrak{N}};$$

und unsere Bedingung wird so ausgedrückt:

$$\Phi_{\mathfrak{N}} \leqq L_{\mathfrak{N}} \qquad (\text{für alle } \mathfrak{N} \leqq \mathfrak{M}).$$

Also können wir nach dem Hilfssatz die Zahlen $\varphi_{\mathfrak{N}_i}$ finden, die den Bedingungen (12) und (13) genügen. Wir teilen die $\varphi_{\mathfrak{N}}$ oben betrachteten Formen in m Klassen, indem wir $\varphi_{\mathfrak{N}_i}$ Formen davon der i-ten Klasse angehören lassen.

Sodann spezialisieren wir die Formen der i-ten Klasse wie folgt:

$$\bar{f} = x_{i\nu}^{\alpha_{\nu i}} \prod_{j\neq i} x_{jn_j}^{\alpha_{\nu j}} \qquad (\nu = 1, 2, \ldots),$$

wobei nach (13) und (15) die Indices ν von einander verschiedene Werte haben dürfen.

Bei dieser Spezialisierung ersieht man leicht, dass zwischen den Formen $[\bar{f}^*]$ keine algebraische Abhängigkeit besteht. Folglich ist nach Satz 2 das Trägheitsideal Nullideal.

Bezeichnet man, im Fall von r Formen in zwei Variablenreihen $x_1, \ldots, x_n$ und $y_1, \ldots y_m$, die Anzahl der nur von x abhängigen Formen, die der nur von y abhängigen und die der x und y enthaltenden Formen bzw. mit φ_x, φ_y und $\varphi_{x,y}$, so erhält man aus dem oberen Satz den

Zusatz. Das Trägheitsideal von Formen $f_1, \ldots, f_r$ in den x und y ist dann und nur dann Nullideal, wenn die folgenden Ungleichungen bestehen:

$$r = \varphi_x + \varphi_y + \varphi_{x,y} \leqq n + m - 2\,,$$

$$\varphi_x \leqq n - 1\,, \quad \varphi_y \leqq m - 1\,.$$

§ 3.

In diesem § untersuchen wir, in welchen Fällen das Trägheitsideal ein vom Nullideal verschiedenes Hauptideal ist.

Satz 6. Wenn für jedes System von Variablenreihen

$$(*) \qquad (5_{h_1})\,, \quad \ldots\ldots, \quad (5_{h_\mu})$$

aus den (5_i) höchstens $\lambda - 1$ Formen aus

$$(4'') \qquad f_1\,, \; f_2\,, \; \ldots\ldots, \; f_{r-1}$$

nur von denselben Variablen aus $(*)$ abhängig sind, so enthält jede von Null verschiedene Trägheitsform von (4), falls solche überhaupt vorhanden ist, den Koeffizient e_ω; und umgekehrt. Dabei bedeutet wie vorher $\lambda = \Sigma n_{h_i} - \mu + 1$.

Beweis. Wenn die oben genannte Bedingung nicht besteht, so hat das System $(4'')$ nach Satz 5 eine von Null verschiedene Trägheitsform, welche offenbar von e_ω unabhängig ist. Also ist unsere Bedingung notwendig.

Wir setzen dann voraus: die Bedingung sei erfüllt.

Angenommen

$$T = T(a_1\,, \ldots\ldots, a_\omega\,; \ldots\ldots; e_1\,, \ldots\ldots, e_{\omega-1})$$

sei eine von e_ω unabhängige, von Null verschiedene Trägheitsform. dann bestehe

$$T(a_1\,, \ldots\ldots, -[f_1^*]\,; \ldots\ldots, -[f_{r-1}^*]\,; e_1\,, \ldots\ldots, e_{\omega-1}) = 0\,.$$

Die Formen $f_i^*(i < r)$ lassen sich aber, wie in § 2, so spezialisieren, dass die $[f_i^*]\,(i < r)$ algebraisch unabhängig sind, was mit der eben angeschriebenen Gleichung im Widerspruch steht, w. z. b. w.

Satz 7. Wenn für mindestens ein System von Variablenreihen wie

$$(*) \qquad (5h_1), \ldots\ldots, (5h_\mu)$$

aus den (5_i) genau λ Formen unter (4) nur von denselben Variablen unter (*) abhängig sind, während für jedes solches System (*) höchstens $\lambda-1$ Formen unter (4') nur von denselben Variablen abhängig sind, so ist das Trägheitsideal der Formen (4) ein vom Nullideal verschiedenes Hauptideal und seine Basis ist von dem Koeffizient e_ω abhängig; und umgekehrt.

Beweis. Es lässt sich wie bei einer Variablenreihe zeigen, dass das Trägheitsideal dann und nur dann durch eine von e_ω abhängige Basis erzeugt wird, wenn alle von Null verschiedene Trägheitsformen den e_ω enthalten.

Dass für mindestens ein System von Variablenreihen (*) genau λ Formen unter (4) nur von denselben Variablen abhängig sind, ist nach Satz 5 notwendig und hinreichend dafür, dass das Trägheitsideal vom Nullideal verschieden ist.

Dass für jedes System von Variablenreihen (*) höchstens $\lambda-1$ Formen unter (4'') nur von denselben Variablen abhängig sind, ist nach demselben Satz notwendig und hinreichend für die Nichtexistenz einer von e_ω unabhängigen Trägheitsform.

Daraus folgt unser Satz sofort.

Satz 8. Die notwendige und hinreichende Bedingung dafür, dass das Trägheitsideal der Formen (4) ein vom Nullideal verschiedenes Hauptideal ist, besteht darin, dass man die Formen f_i irgendwie umnumerieren kann, so dass die Bedingungen im vorigen Satz erfüllt werden.

Beweis. Wenn das Trägheitsideal ein vom Nullideal verschiedenes Hauptideal ist, so ist seine Basis mindestens von einem Koeffizient der Formen f_i abhängig. Also folgt der Satz sofort aus dem vorigen.

Die Bedingung dieses Satzes besagt für den Fall zweier Variablenreihen, dass nach geeigneter Umnumerierung von f_i mindestens eine der Gleichungen

$$\varphi_x = n\,, \quad \varphi_y = m\,, \quad \varphi_x + \varphi_y + \varphi_{x,y} = n + m - 1$$

und alle drei Ungleichungen

$$\varphi'_x \leqq n-1\,,\ \varphi'_y \leqq m-1\,,\ \varphi'_x + \varphi'_y + \varphi'_{x,y} \leqq n+m-2$$

bestehen sollen, wobei φ_x, φ_y und $\varphi_{x,y}$ dieselben Bedeutungen wie in §2 haben und φ'_x, φ'_y und $\varphi'_{x,y}$ die entsprechenden Bedeutungen für die Formen $f_1, \ldots, f_{r-1}$ wie φ_x, φ_y und $\varphi_{x,y}$ für $f_1, \ldots, f_r$.

Daraus folgt leicht der

Zusatz. Das Trägheitsideal der Formen $f_1, \ldots, f_r$ in zwei Variablenreihen x und y ist dann und nur dann ein vom Nullideal verschiedenes Hauptideal, wenn man die Formen f_i irgendwie umnumerieren kann, so dass eine der folgenden drei Beziehungen besteht:

1) $r = n+m-1\,,\quad \varphi'_x \leqq n-1\,,\quad \varphi'_y \leqq m-1\,,$

2) $r \leqq n+m-2\,,\quad \varphi_x = n$

und

3) $r \leqq n+m-2\,,\quad \varphi_y = m\,.$

§ 4.

Definition. Wenn das Trägheitsideal der Formen $f_1, \ldots, f_r$ in m Variablenreihen ein vom Nullideal verschiedenes Hauptideal ist und seine Basis sämtliche Koeffizienten derselben Formen enthält, so nennen wir diese Basis eine m-reihige Resultante von $f_1, \ldots, f_r$, welche durch $R(f_1, \ldots, f_r)$ bezeichnet wird.

Es bedeute $l = \Sigma n_i - m + 1$, d.h. l bedeute die λ-Zahl für die sämtlichen Variablenreihen.

Satz 9 (Hauptsatz 2). Damit für die r allgemeinen Formen f_1, $f_2, \ldots, f_r$ die m-reihige Resultante $R(f_1, f_2, \ldots, f_r)$ existiert, ist notwendig und hinreichend, dass $r = l$ ist und dass für jedes System $(*)$ von Variablenreihen mit $\mu < m$ höchstens $\lambda - 1$ Formen unter f_i nur von denselben Variablen aus $(*)$ abhängig sind.

Beweis. Damit das Trägheitsideal ein Hauptideal sein soll und seine Basis von allen Koeffizienten abhängig sein soll, ist notwendig und hinreichend, dass die Bedingung im Satz 7 bei jeder Numerierung von f_i erfüllt sei.

Daher müssen, bei einer Numerierung, für irgendein System von Variablenreihen

$$(**) \qquad (5k_1), \quad \ldots\ldots, \quad (5k_{\bar{\mu}})$$

genau $\bar{\lambda}$ Formen unter (4) nur von denselben Variablen aus (**) abhängen, wobei $\bar{\lambda}$ die λ-Zahl zum System (**) bedeutet.

Wenn es unter (4) ausser diesen $\bar{\lambda}$ Formen eine andere Form gibt, so könnte man diese Formen so umnumerieren, dass der letzte Teil der Bedingung vom Satz 7 nicht gelten würde.

Daher muss $\bar{\lambda} = r$ sein, d.h. alle Formen (4) nur von (**) abhängen, woraus unmittelbar $\bar{\mu} = m$ folgt. Daraus folgt weiter $r = \bar{\lambda} = l$.

Somit ist die Notwendigkeit der $r = l$ erwiesen.

Die Notwendigkeit des letzteren Teils der Bedingung lässt sich leicht zeigen.

Ferner zeigt man ohne Schwierigkeit, dass die Bedingung hinreichend ist.

Wenn das Trägheitsideal ein vom Nullideal verschiedenes Hauptideal ist, so können wir zwei Fälle unterscheiden:

1° Die Basis ist m-reihige Resultante,

2° Sonstige Fälle.

In dem letzteren Fall wird, wie man leicht sieht, die Basis des Trägheitsideals eine geringer-reihige Resultante als eine m-reihige.

Der Grad der m-reihigen Resultante $R(f_1, \ldots\ldots, f_l)$ lässt sich ganz genau wie im Fall der 2-reihigen bestimmen.

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Beiträge zur Kenntnis pflanzlicher Nukleolen

Von

G. YAMAHA und S. SUEMATSU

[Mit Tafeln VI u. VII]

(Eingegangen am 5. Sept. 1936)

Einleitung

Von verschiedenen Streitfragen über pflanzliche Nukleolen, die seit längst immer wieder ins Feld geführt wurden, scheint diejenige vom Standpunkt der Chromosomenlehre (Chromosomologie) die bedeutsamste und interessanteste zu sein, welche sich mit der Beziehung der Nukleolen zu Chromosomen befasst. Die betreffende Frage wurde dabei vorwiegend von der zytomorphologischen Seite aus, aber nur selten von der mikrochemischen Seite aus angegriffen. In dieser Beziehung wäre es sehr wünschenswert, bei den sogenannten euchromozentrischen Kernen, d. h. den karyotinarmen Kernen nach YAMAHA[1] das Verhalten des Nukleolus im Laufe der Karyokinese genau zu verfolgen, und zwar mit Hilfe der FEULGENschen Nukleal-Färbung.

In unserer früheren Mitteilung[1] haben wir darauf aufmerksam gemacht, dass mikrochemischer Reaktion nach der Nukleolus auch bei euchromozentrischen Kernen zu Karyotin sowie Chromosomen in schroffenem Gegensatz steht, trotzdem diesbezügliche zytomorphologische Befunde häufig den genetischen Zusammenhang zwischen beiden Karyoplasmen während der Karyokinese vermuten lassen. Im letztgenannten Sinne vermehren sich bis in die neueste Zeit Angaben immer wieder.[2]

1) YAMAHA & SINOTÔ (1925)

2) vgl. z. B. SOROKIN (1927, 1929), SCHAEDE (1929), SCHILLER (1928), ZIRKLE (1928, 1931), LATTER (1926, 1932), MCCLINTOCK (1929), INOUE (1929, 1930, 1931, 1932), TRANKOWSKY (1930), MARSHAK (1931), HEITZ (1931, 1932), CHRISTOFF u. GENTSCHEFF (1932), HAASE-BESSEL (1932), KOTLIAREWSKAJA (1932), BLUNT (1933), BEADLE (1933), SMITH (1933), LENOIR (1934), VAN CAMP (1934) usw.

In vorliegenden Untersuchungen wurde auf die Nukleal-Reaktion verschiedener Elemente des Karyoplasmas im Laufe der Karyokinese eine besondere Rücksicht genommen, um uns über die angebliche gegenseitige Beziehung zwischen beiden Karyoplasmen irgendeinen Aufschluss verschaffen zu können.

Methodisches

Als Untersuchungsmaterial kommen in erster Linie die Wurzelspitzen von Cucurbitaceen in Betracht, und zwar von folgenden Arten:

Cucumis sativus L., *Cucumis Melo* L. var *albus* MAKINO, *Cucumis Melo L.* var. *Makuwa* MAKINO, *Citrullus vulgaris* SCHRAD., *Lagenaria vulgaris* SER. var. *Gourda* SER., *Luffa cylindrica* ROEM., *Trichosanthes cucumeroides* MAXIM., *Cucurbita moschata* DUCH. var. *Toonas* MAKINO, *Momordica Carantia* L.

Weiterhin wurden zum Vergleich die Wurzelspitzen von *Ricinus communis* L., *Impatiens Balsamina* L., *Gladiolus* sp., *Glycine Soja* BENTH., *Allium Cepa* L., *Zea Mays* L., *Triticum vulgare* VILL. und *Chrysanthemum nipponicum* MATSUMURA herangezogen. Zur Fixierung kommen Sublimatessigsäure (4g. Sublimat, 3g. Eisessig, 100 ccm. Wasser) und 70 proz. Alkohol zur Anwendung, welch beide bekanntlich im allgemeinen starke Nukleal-Färbung ergeben (YAMAHA 1932). Die in Paraffin eingebetteten Wurzelspitzen wurden 7–10 μ dick geschnitten. Fuchsinschweflige Säure wurde nach der Vorschrift von FEULGEN u. ROSSENBECK (1924) hergestellt. Die Hydrolyse der Schnitte dauerte 5–6 Minuten bei 60°C and darauf folgte die Färbung mit fuchsinschwefliger Säure (Färbedauer 5–7 Stunden). Hydrolysiertes Material wurde neben dem nicht hydrolysierten auch mit HEIDENHAINschem Eisenhämatoxylin gefärbt. Sowohl bei Nukleal-Färbung als auch bei Eisenhämatoxylinfärbung erwies sich Gegenfärbung mit Lichtgrün häufig sehr wertvoll.

Beobachtungen

1. **Ruhekern.** In dem Wurzelmeristem der obengenannten Arten von Cucurbitaceen sowie von *Impatiens Balsamina* und *Ricinus communis* beobachtet man in der Kernperipherie eine bestimmte Anzahl von den mit fuchsinschwefliger Säure rötlich violett gefärbten

Karyotingranula (Chromozentren), welche in dem schwach nukleal gefärbten Kernsaft eingebettet erscheinen. Bemerkenswert ist noch, dass sich auch die in der Regel vakuolenhaltigen Nukleolen mit fuchsinschwefliger Säure wenn auch schwach, doch deutlich gefärbt zeigen. Die Nukleal-Färbung der Nukleolen ist zwar merklich schwächer als bei den Chromozentren, aber immer etwas stärker als bei dem Kernsaft. Jedes nukleal positive Element des Karyoplasmas hebt sich deutlich von dem nukleal negative Zytoplasmas ab (Fig. 1, 19, 23, 29, 33, 37, Tafel VI; Fig. 42, 47, 49, 54, 65, 69, Tafel VII). In der Streckungszone sowie in der Wurzelhaube finden wir in dem Kern neben zahlreichen Karyotingranula von verschiedenen Grössen verschwommenes Kernretikulum. In diesem Fall reagiert auch der Nukleolus ebenfalls nukleal positiv, und zwar färbt er sich ebenso stark oder etwas schwächer wie das Kernretikulum (Fig. 10, Tafel VI).

Ebendieselbe Kernstruktur macht sich auch bei Hämatoxylin-Material bemerkbar, nur dass sich der Nukleolus hier ebenso stark färbt wie die Karyotingranula, und weiter dass sich der Kernsaft in der Regel kaum färbt (Fig. 13, Tafel VI).

Bei *Ricinus communis* und *Glycine Soja* ist in der Kernperipherie neben Chromozentren zartes Retikulum bemerkbar (Fig. 60, 65, Tafel VII). Der Kernsaft von *Gladiolus* zeichnet sich dadurch aus, dass er ausser scharf hervortretenden Chromozentren mit zahlreichen winzigen Körnchen gleichmässig dicht besät ist. Die fragliche Körnelung reagiert deutlich nukleal positiv und verdichtet sich um den Nukleolus herum (Fig. 49, Tafel VII).

Im Gegensatz zu den obengenannten euchromozentrischen (karyotinarmen) Kernen zeigen die karyotinreichen Kerne von *Allium Cepa, Triticum vulgare, Zea Mays* und *Chrysanthemum nipponicum* ausgeprägtes Retikulum (Karyotinnetz), welches sich mit fuchsinschwefliger Säure intensiv färbt, während sowohl der Nukleolus als der Kernsaft nukleal negativ ausfallen.

2. Prophase. Wenn sich der euchromozentrische Kern anschickt, sich zu teilen, nehmen die Chromozentren etwas an Grösse zu (Fig. 2, 20, 24, Tafel VI usw.). Am häufigsten bemerkt man dabei, dass die Zahl dieser Chromozentren mit der Chromosomenzahl in der Metaphase übereinstimmt. Bald erscheinen an einem oder beiden Enden jedes Chromozentrums fädige nukleal schwach gefärbte Anhängsel und verlängern sie sich in dem Kernsaft (Fig. 3, 4,

21, 24, 30, 34 Tafel VI u. s. w.). Einige von ihnen gelangen an die Oberfläche des Nukleolus und scheinen mit dem letzteren zur Verbindung zu kommen. Die betreffenden Verbindungsfäden treten dann besonders deutlich hervor, wenn man zur Gegenfärbung Lichtgrün anwendet (Fig. 5, 6, Tafel VI; Fig. 50, Tafel VII u. s. w.).

Bei *Cucumis Melo* sieht man nicht selten die beiden Hälften jedes schon längsgespalteten Chromozentrums lang ausgezogen und zueinander parallel verlaufen (Fig. 38, 39, Tafel VI). Bei *Glycine Soja, Trichosanthes cucumeroides* und *Gladiolus* sp. geht das Verschwinden der sichtbaren Karyotinstrukturen, d. h. des Kernretikulums und zarter Karyotingranula der Entwicklung der Chromozentren voran, welch letztere auch hier wieder in der oben erwähnten Weise erfolgt (Fig. 50, 51 67, 70, Tafel VII).

Gegen Ende der Prophase wird die Nukleal-Färbung des Nukleolus sowie des Kernsaftes immer schwächer, um schliesslich kaum sichtbar zu werden (Fig. 7, 30, 31, Tafel VI; Fig. 45, 57, Tafel VII). Diese Färbbarkeitsverminderung beider Komponente des Karyoplasmas gegen Ende der Prophase bedeutet ohne weiteres die Abnahme des Nukleinsäuregehaltes der betreffenden Strukturelemente, was eine besondere Beachtung verdient.

3. Metaphase und Anaphase. Bei den euchromozentrischen Kernen entwickeln sich im allgemeinen verhältnismässig kleine kugelige oder stäbchenförmige Chromosomen in der Metaphase. In der Kernplatte lassen sich Chromosomenzahlen folgendermassen feststellen:

Cucumis sativus 2n = 14 (Fig. 16), *Cucurbita moschata* var. *Toonas* 2n = 24 (Fig. 22), *Luffa cylindrica* 2n = 26 (Fig. 27), *Citrullus vulgaris* 2n = 22 (Fig. 32), *Cucumis Melo* var. *Makuwa* 2n = 24 (Fig. 35), *Cucumis Melo* var. *albus* 2n =24, *Lagenaria vulgaris* var. *Gourda* 2n = 22 (Fig. 46), *Momordica Carantia* 2n = 22 (Fig. 48), *Trichosanthes cucumeroides* 2n = 44 (Fig. 71), *Impatiens Balsamina* 2n = 14 (Fig. 58), *Ricinus communis* 2n = 20 (Fig. 63), *Gladiolus* sp. 2n = 30 (Fig. 52), *Glycine Soja* 2n = 38 (Fig. 68).

Bei dem Hämatoxylin- sowie Lichtgrün-Material bemerkt man im allgemeinen in der Kernplatte, wie in der Anaphase, neben Chromosomen, den sogenannten Restnukleolus bzw. persistenten Nukleolus deutlich, welcher aber nukleal negativ reagiert, also bei dem Fuchsinschwefligsäure-Material ohne′ Gegenfärbung immer unsichtbar bleibt (Fig. 11, 12, 17, Tafel VI). Bei *Allium Cepa, Triticum vulgare*

und *Chrysanthemum nipponicum* waren Restnukleolen auch bei Hämatoxylinfärbung selten angetroffen. Nach alledem ist zu folgern, dass der sogenannte Restnukleolus in der Metaphase und Anaphase keine Nukleinsäure enthält, und weiter, dass man aus der Färbbarkeit mit Eisenhämatoxylin auf den Nukleinsäuregehalt nicht schliessen darf.

4. Telophase. Nach der Bildung der Kernmembran treten bald ein oder mehrere mit Hämatoxylin färbbare Klumpen unregelmässiger Gestalt in die Erscheinung, die häufig mit den degenerierenden Chromosomen in Verbindung stehen. Diese Klumpen runden sich dann ab, um typische Nukleolen zu bilden. Die neugebildeten Nukleolen, welche aber selten vakuolisiert erscheinen, reagieren übrigens schwach nukleal positiv, wie in der Prophase (Fig. 8, 9, 36, 40, Tafel VI; Fig. 53, 64, Tafel VII).

Kataphoretische Versuche

Um über die Ladungsverhältnisse des Nukleolus gegenüber dem Karyotin im klaren zu sein, stellten wir eine Reihe von kataphoretischen Versuchen an. Als Versuchsmaterial wurden die 2,0–2,5 cm langen Keimwurzeln von *Cucumis sativus* angewandt. Die Wurzelspitze wurde in ein mit angefeuchtem Kaolin oder 0,1 n KCl-Agarlösung gefülltes Glasröhrchen eingesteckt, welches eine unpolarisierte Elektrode ausmachte. Als die andere Elektrode diente ein Stückchen Platindraht, dessen Spitze man durch die Samenschale stach. Stromstärke betrug 0,1–2,0 milliampère, und Spannung 100 oder 150 volt. Sofort nach der Durchströmung, die 30 Sekunden bis 8 Minuten dauerte, wurden die Wurzelspitzen mit Sublimatessigsäure fixiert und weiter wie oben behandelt.

Die Versuchsergebnisse erwiesen sich merklich verschieden zwischen der meristematischen Zone und der Streckungszone des Wurzelvegetationspunktes. Der Unterschied hängt nämlich damit zusammen, dass jeder Zellbestandteil in der Streckungszone durch elektrischen Strom leichter verlegbar erscheint als in der Teilungszone (Meristem), wo die Kataphorese dementsprechend erst bei höherer Stromintensität (z. B. 2 milliampère, 1 Minute) oder bei längerer Wirkungsdauer (z. B. 0,3 milliampère, 8 Minuten) sichtbar wird. Dieser Umstand steht mit der Fastigialtheorie im Einklang, nach welcher das Protoplasma in embryonalem Zustand dem Ladungs-

minimum (seinem isoelektrischen Punkt) näher liegen soll als in erwachsenem Zustand (YAMAHA u. ISHII 1933). In diesem Zusammenhang ist hier hervorzuheben, dass die sämtlichen karyoplasmatischen Strukturen immer nach der Anode wandern, während das Zytoplasma jenach der Stromstärke bzw. der Dauer der Durchströ-

Minuten	Milliampère		1,8	1,4	1,2	1,0	0,8	0,5	0,4	0,3	0,2	0,1
0,5	K	S						±	±	±		
		T						±	±	±		
	Z	S						+	+	+		
		T						+	+	+		
1,0	K	S	±	±	±	±	±	±	±	±	±	±
		T	±	±	±	±	±	±	±	±	±	±
	Z	S	—	+	+	+	+	+	+	+	+	+
		T	+	+	+	+	+	+	+	+	+	+
2,0	K	S			—		—		±	±	±	±
		T			±		±		±	±	±	±
	Z	S			—		—		+	+	+	+
		T			+		+		+	+	+	+
2,5	K	S				—	—					
		T				±	±					
	Z	S				—	—					
		T				—	+					
3,0	K	S						±		±	±	
		T						±		±	±	
	Z	S						—		—	+	
		T						+		+	+	

K bedeutet Karyoplasma, Z Zytoplasma, S Streckungszone, T Teilungszone, + Wanderung nach der Kathode, — Nach der Anode, ± Keine Wanderung.

mung bald nach der Kathode bald nach der Anode wandert, wie die vorstehende Tabelle veranschaulicht.

Der Zellkern, wenn er überhaupt durch elektrischen Strom verlegt wird, wandert ohne Ausnahme nach der Anode. Gleichzeitig werden die Nukleolen mitsamt den Chromozentren und dem Kernsaft auf der Anodenseite in dem Kernraum verschoben, was auf die negative Ladung dieser Karyoplasmen schliessen lässt. Mitunter erfährt der Zellkern auf seiner Anodenseite eine knospen- oder säckchenartige Vorwölbung, in welche sämtliche nukeal-positiv reagierende Karyoplasmen gewöhnlich hineingewandert erscheinen (Fig. 72, 73, 75, Tafel VII). Diese nukleolushaltige Kernknospe kann weiter abgeschnürt werden (Fig. 74, Tafel VII). Das Gesamtbild erinnert an dasjenige, welches NĚMEC (1929) seinerzeit mit Zentrifugieren erzielt hat. Aus alledem ist ohne weiteres zu schliessen, dass der Nukleolus ebenso negativ geladen ist wie Karyotingranula, was auch in der Metaphase und Anaphase zu gelten scheint. Denn man bemerkt in diesen Mitosenstadien nur die Verschiebung der ganzen Mitosenfigur samt Restnukleolen und Chromosomen nach der Anodenseite der Zelle.

Was das Zytoplasma anbelangt, so wechselt die Richtung der kataphoretischen Wanderung desselben jenach der Stromstärke sowie der Wirkungsdauer (vgl. Tabelle). Es hat den Anschein, als ob das Zytoplasma in lebendem Zustand positive Ladung trägt (Fig. 75, Tafel VII), während beim Zellentod eine negative Umladung auftritt, wie schon früher von HARDY (1913), HEILBRUNN (1928, S. 166ff.) hevorgehoben wurde. Da die Empfindlichkeit des Protoplasmas gegenüber der Elektrizität mit dem Zellenalter zuzunehmen scheint, so lässt sich in der Übergangszone der Wurzelspitze zwischen der meristematischen und Streckungszone bei einer bestimmten Stromintensität und Wirkungsdauer der Umschlag der Wanderungsrichtung des Zytoplasmas bemerken.

Besprechung der Ergebnisse

Es verdient zunächst eine besondere Beachtung, dass bei euchromozentrischen Kernen der Nukleolus und der Kernsaft, wenn auch schwach, immer nukleal positiv reagieren. Nach bisheriger diesbezüglicher Literatur hat aber TISCHLER (1934, S. 67) den Schluss gezogen, dass den Nukleolen, zum mindesten der pflanzlicher Organis-

men, jede Spur von Thymonukleinsäure fehlt, und vereinzelte gegenteilige Angaben hat er auf technische Fehler bei der Ausführung der Nukleal-Reaktion zurückgeführt. Wir möchten dagegen hier hervorheben, dass der euchromozentrische Kern kein einziges Beispiel für den nukleal positiven Nukleolus aus Pflanzenwelt bietet. Wir haben doch schon früher auch bei mehreren Arten von Bryophyten (z. B. *Pellia Neesiana*) auf die positive Nukleal-Reaktion des Nukleolus aufmerksam gemacht (YAMAHA 1935). Hier bemerkt man, wie bei euchromozentrischen Kernen, auch innige Beziehung des Nukleolus zur Chromosomenbildung in der Prophase (vgl. LORBEER 1934).

Im übrigen darf man nicht vergessen, dass Nukleal-Reaktion keinen zwingenden Beweis für den Thymonukleinsäuregehalt einer bestimmten Struktur erbringen kann, sondern nur das Vorhandensein des Desoxyzuckers nachweisen lässt. Es erscheint also dringend notwendig, zu noch anderen mikrochemischen Reaktionen für Nukleinsäure unsere Zuflucht zu nehmen, damit man die angebliche Nukleinsäurehaltigkeit des Nukleolus bestätige.

Da der Ausfall der Nukleal-Reaktion leicht mit technischem Fehler behaftet sein kann, so möchten wir hier einige methodische Bemerkungen vorausschicken.

Es ist schon früher gezeigt, wie verschiedenartige Fixiermittel Nukleal-Färbung in verschiedenen Massen beeinflussen. Nukleal-Färbung wird durch die sublimathaltigen Fixiermittel begünstigt (YAMAHA 1932). In diesem Zusammenhang ist nebenbei zu bemerken, dass selbst die Stärkekörner, mit 1 proz. Chromsäure fixiert, sich nukleal stark färben.

Wir haben uns schon früher davon überzeugt, dass die Dauer der Hydrolyse der Nukleal-Färbung den Ausschlag gibt (YAMAHA 1935). Das ist besonders dann der Fall, wenn es sich um eine schwache Reaktion handelt. Man gedenke nur der Hefezellen, welche nur dann äusserst schwache Nukleal-Färbung geben, wenn die Hydrolyse bei 60° C 4–8 Minuten dauert.

Als das dritte Moment für den Ausfall der Nukleal-Reaktion wäre Färbedauer genannt. Je länger dauert die Färbung, um so stärker wird die Färbung. Demzufolge muss die Färbung bei schwacher Reaktion möglichst lang dauern (sogar bis 24 Stunden).

Bemerkenswert sei nun weiter, dass bei dem in Paraffin eingebetteten Material der Zellkern mit fuchsinschwefliger Säure nicht

so stark sich färbt, wie bei dem frischen aber fixierten Material. Eine besondere Reihe von Versuchen ergeben, dass die Behandlung mit Alkohol und Tetrachlorkohlenstoff, Chloroform usw. die Nukleal-Färbung einigermassen beeinflusst, so dass man eine stärkere Nukleal-Färbung erzielen kann, wenn Färbung sofort auf das Auswaschen des fixierten Materials folgt, d. h. der Entwässerung mit Alkohol vorangeht. Die erzielte Nukleal-Färbung wird durch weitere Behandlung des Materials nicht merklich beeinflusst.

Die Nukleal-Reaktion des Nukleolus und des Kernsaftes findet man niemals bei gewöhnlichen, d. h. karyotinreichen Kernen. Bei euchromozentrischen Kernen erweist sich die Nukleal-Reaktion bei den Nukleolen und dem Kernsaft ungleich schwächer als bei dem Karyotin und den Chromosomen und nur in der Prophase bemerkbar. Gegen Ende der Prophase wird die Färbung immer schwächer, um in der Metaphase verschwinden zu gehen. Der Nukleolus und Kernsaft enthalten also höchstwahrscheinlich eine kleine Menge von Thymonukleinsäure, die in Laufe der Prophase verbraucht wird. Die sogenannten Restnukleolen in der Metaphase und Anaphase scheinen von Nukleinsäure befreit zu sein, und fallen allem Anschein nach im Zytoplasma der Degeneration anheim. (vgl. YAMAHA & SINOTÔ 1925, FREW & BOWEN 1929, SCHAEDE 1929, EICHHORN 1933).

Restnukleolen wurden bisher bei folgenden Gattungen gefunden:

Algen: *Spirogyra* (CONARD 1931), *Cladophora* (GEITLER 1936)

Bryophyten: *Anthoceros* (LORBEER 1924)

Pteridophyten: *Pteris, Hymenophyllum* (LITARDIÈRE 1921), *Marsilea* (BERGHS 1907, LITARDIÈRE 1921)

Moraceen: **Cannabis* (YAMAHA & SINOTÔ 1925)

Chenopodiaceen: *Beta* (YAMAHA & SINOTÔ 1925)

Cruciferen: *Brassica* (YAMAHA & SINOTÔ 1925)

Leguminosen: **Glycine* (YAMAHA & SINOTÔ 1925, CHRISTOFF u. GENTSCHEFF 1932), **Canavalia*, **Dolichos* (YAMAHA & SINOTÔ 1925), **Lupinus* (GEORGEWITCH 1908, SCHAEDE 1929), **Phaseolus* (WAGER 1904, YAMAHA & SINOTÔ 1925), *Pisum* (SCHAEDE 1929), *Vicia* (LUNDEGÅRDH 1912, FRASER 1914, YAMAHA & SINOTÔ 1925, SCHAEDE 1929, CHRISTOFF u. GENTSCHEFF 1932, KOTLIAREWSKAJA 1932), **Vigna* (YAMAHA & SINOTÔ 1925)

Euphorbiaceen: **Ricinus* (YAMAHA & SINOTÔ 1925)

Aceraceen: *Acer* (MOTTIER 1914)

Balsaminaceen: ***Impatiens***

Malvaceen: **Gossypium*, **Hibiscus* (MAGITT 1928)
Convolvulaceen: *Ipomoea* (YAMAHA & SINOTÔ 1925)
Solanaceen: **Solanum*, **Lycopersicum* (YAMAHA & SINOTÔ 1925)
Orobanchaceen: *Lathraea* (GATES & LATTER 1927)
Cucurbitaceen: **Cucurbita* (YAMAHA & SINOTÔ 1925, FREW & BOWEN 1929, EICHHORN 1931), **Cucumis* (YAMAHA & SINOTÔ 1925, PASSMORE 1930, EICHHORN 1931, KOTLIAREWSKAJA 1932), **Citrullus* (PASSMORE 1930), **Luffa* (PASSMORE 1930), ****Lagenaria***, ****Trichosanthes***, ****Momordica***
Kompositen: **Helianthus* (ROSEN 1896, TAHARA 1915, YAMAHA & SINOTÔ 1925)
Gramineen: *Zea* (MAINX 1924, ZIRKLE 1928, CHRISTOFF u. GENTSCHEFF 1932)
Liliaceen: *Allium* (GEORGEWITCH 1908, LUNDEGARDH 1912, SCHUSTOW 1913, REED 1914, SCHAEDE 1929, KOTLIAREWSKAJA 1932), *Fritillaria* (STRASBURGER 1880, 1884) *Hyacinthus* (SCHAEDE 1929), *Lilium* (SCHAEDE 1929), *Tricyrtis* (IKEDA 1902)
Amaryllidaceen: *Clivia* (VAN CAMP 1924), *Galanthus* (STRASBURGER 1880, 1884)
Iridaceen: *Iris* (SCHAEDE 1929), **Gladiolus* (YAMAHA & SINOTÔ 1925)
Cannaceen: *Canna* (TOKUGAWA & KUWADA 1924, SCHAEDE 1929)

Die Restnukleolen machen sich manchmal (bei den mit * versehenen Gattungen), aber nicht ausschliesslich bei den euchromozentrischen Kernen bemerkbar, wie man aus der obenstehenden Tabelle ersehen kann. Nach KOTLIAREWSKAJA (1932) sind sie ungleich häufiger bei den euchromozentrischen Kernen anzutreffen als bei den karyotinreichen Kernen.

Auffallend ist, dass die euchromozentrischen Kerne von einer Reihe von karyologischen Eigentümlichkeiten begleitet sind. So z. B.:

1. Im Ruhezustand kommt ihnen nur spärliche färbbare Substanz (Karyotin), dementsprechend kaum oder wenig Reitikulum zu. Wir bezeichnen sie also mitunter "karyotinarme Kerne".

2. Im Gegensatz zur Karyotinarmut zeichnen sie sich durch einen ausgeprägten Nukleolus aus, der oft doppelt kontouriert und mit Vakuolen versehen ist. Der Nukleolus ist im Vergleiche zum Karyotin weniger färbbar oder leichter entfärbbar (z. B. mit Eisenhämatoxylin). Bei den karyotinreichen Kernen zeigt sich das Verhältnis umgekehrt, d. h. das Karyotin pflegt minder färbbar (baso-

phil) zu sein als der Nukleolus. Ausserdem reagiert der Nukleolus mitsamt dem Kernsaft schwach nukleal positiv.

3. Der Nukleolus bleibt noch in der Metaphase und Anaphase zurück, obwohl er seine Nukleal-Reaktion schon einbüsst.

4. Die Chromosomen sind verhältnismässig klein und gestalten sich kugelig oder stäbchenförmig.

5. In der Telophase bilden sich eine bestimmte Anzahl von kleinen Nukleolen in beiden Tochterkernen in symmetrischer Lage.

Vorliegende Untersuchungen machen es wahrscheinlich, dass die sogenannten Chromozentren in der Prophase, die am häufigsten mit Metaphasechromosomen in Zahl übereinstimmen, die Grundlage der letzteren darstellen (vgl. HEITZ 1931, 1932, DOUTRELIGNE 1933 usw.). Im Laufe der Prophase verlängern sich die einzelnen Chromozentren innerhalb des Kernraumes und kommen mitunter mit dem Nukleolus zur Verbindung. Gegen Ende der Prohase verkürzen sie sich wiederum, um schliesslich die kugelige Form der Chromosomen anzunehmen. Diese Verlängerung einzelner Chromozentren in der Prophase, welche die Vergrösserung ihrer Oberflächen zur Folge hat, scheint die Aufnahme der Nukleinsäure vom Aussen her zu begünstigen.

Kataphoretische Versuche erwiesen sich nicht befriedigend, um die Ladungsverhältnisse einzelner Karyoplasmen festzustellen, weil in den meristematischen Zellen die freie Ladung des Protoplasmas minimal zu sein scheint, so dass die Kataphorese einzelner Strukturelemente bei minimaler wirksamer Stromintensität unsichtbar bleibt. Es wäre auch denkbar, dass die erzielte kataphoretische Verlegung schnell rückgängig wird, bevor sie fixiert worden ist, was eine niedere Viskosität des Protoplasmas in embryonalen Zellen voraussetzt. Auf diese Frage werden wir an einem anderen Ort eingehen;, nur weisen wir hier auf eine bisher oft übersehene Tatsache hin, nämlich dass die Rückgangsgeschwindigkeit der durch das Zentrifugieren oder die Elektrizität verlegten Strukturelemente als Mass der Protoplasmaviskosität bzw. -elastizität betrachtet werden kann.

Jedenfalls steht soviel fest, dass der Nukleolus ebenso wie die Chromozentren und Chromosomen mit negativer Elektrizität beladen ist, was der Schlussfolgerung aus den Färbungsversuchen von KUWADA u. SUGIMOTO (1928) anscheinend widerspricht. Nach unseren Untersuchungen über den isoelektrischen Punkt und die Wasserstoffionenkonzentration der pflanzlichen Protoplasten (YAMAHA 1935b, 1936) muss man hingegen die stärkere negative Ladung des Nukleolus im Vergleich zum Karyotin annehmen.

Zusammenfassung

1. In den sogenannten euchromozentrischen Kernen aus Cucurbitaceen und einigen anderen Pflanzen reagiert der Nukleolus, wenn auch schwach, aber deutlich nukleal positiv; auch der Kernsaft gibt einwandfrei schwache Nukleal-Reaktion.

2. Diese positive Nukleal-Reaktion des Nukleolus und des Kernsaftes verschwindet am Ende der Prophase, so dass der sogenannte Restnukleolus in der Metaphase und Anaphase keine Nukleal-Reaktion mehr zeigt.

3. Der Restnukleolus scheint im Zytoplasma Degeneration zu erfahren und an der Bildung der kleinen Nukleolen in den Telophasenkernen nicht telzunehmen.

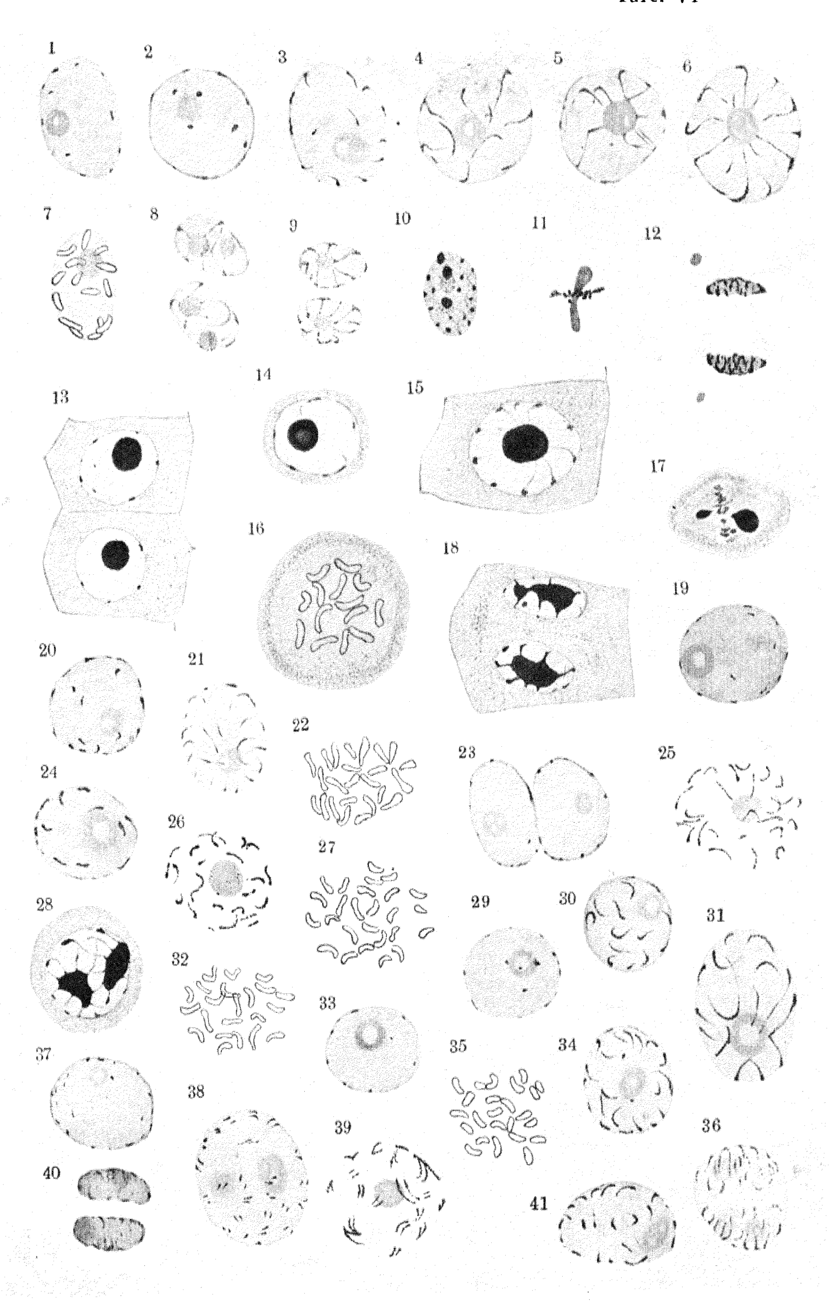
4. Die Chromozentren in der Prophase, welche aller Wahrscheinlichkeit nach die Grundlage der Metaphasechromosomen darstellen, nehmen im Laufe der Prophase Nukleinsäure vom Aussen her, d. h. aus dem Nukleolus und dem Kernsaft in sich auf.

5. Der Nukleolus ist, nach der Kataphorese beurteilt, elektrisch negativ geladen.

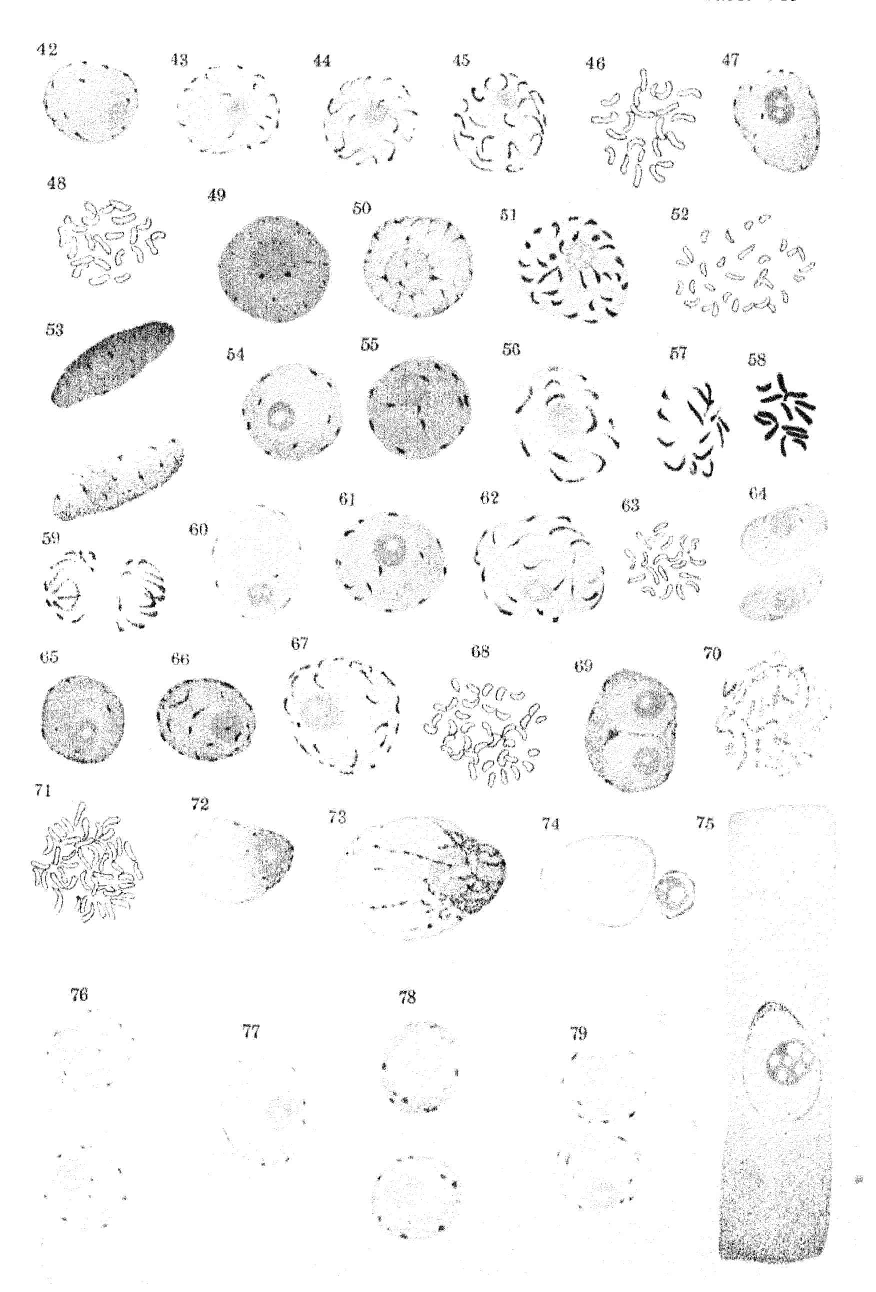
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G. YAMAHA u. S. SUEMATSU: Pflanzliche Nukleolen



G. YAMAHA u. S. SUEMATSU: Pflanzliche Nukleolen

Karyological Study of *Spirogyra* by Means of Nucleal-reaction

By

S. SUEMATSU

[With Plate VIII]

(Received September 10th, 1936)

Introduction

For a long time, a number of studies have been published about the nucleus and the nuclear division of *Spirogyra*. The literature on this subject is reviewed recently by YUASA (1935). According to previous studies (PETTER 1933, SHINKE & SHIGENAGA 1933, YAMAHA 1935), the nucleus of *Spirogyra* does not show nucleal-reaction[1]. GEITLER (1935), however, has lately observed in the resting nuclei of three species of *Spirogyra* (*S. majuscula, S.* X. and *S.* C.) twenty-three to twenty-four chromatic granules that present nucleal-reaction and he named them chromocenters. From this observation he concluded that the nucleus of *Spirogyra* is the same in structure and substance as that of higher plants.

Like GEITLER, the author has also observed in three species of Japanese *Spirogyra* the chromatic granules and chromosomes, both presenting nucleal-reaction. The details of his observation is given in the following.

Material and Method

The specific names of the *Spirogyras* used as the material of observation are not clear. They are collected in the botanical gardens of the university. A was vegetating in the pool from the end of February. B and C were cultured in aquarium and were kept for

1) According to YAMAHA (1935), the isoelectric point of the nucleus of *Spirogyra* is, as in the case of other nuclei that do not present nucleal-reaction, a little more alkaline (pHi 3.4) than that of nuclei showing nucleal-reaction (e. g. pHi 2.9 in the leaf of *Vicia Faba*).

more than six months. Early in the morning, when the temperature of the water was 14–15°C., we fixed the material with alcohol (80%). Nuclear division was then observed abundantly in the living material. After the fixation of the material, we hydrolysed it with n-hydrochloric acid for 5–6 minutes at the temperature of 61°C. After the hydrolysis we put the material in the fuchsin-sulphurous acid and kept it there for 3–4 hours; and then washed it in the dilute sulphurous acid for 14–16 hours and mounted it in Canada balsam.

Observation

1. The resting nucleus: There are one to three nucleoli in the lens-shaped nucleus in which we can observe, instead of what we call reticulum, twenty-four violet-stained granules, the size of which is almost the same. Both in fixed material and in living one we often find vacuoles in the nucleolus (Fig. 1, 2, 14).

2. Prophase: In this stage, the nucleus increases in volume and assumes a round shape (Fig. 3). The nucleolus decreases in size, while the granules grow thicker and elongate a little in their position. Afterwards, the granules gather round the nucleolus as in the nuclei of higher plants containing prochromosomes (Fig. 4). At last, the nucleolus loses its round shape and becomes an obscure mass of irregular form in the centre of the nucleus (Fig. 4, 5, 6, 15). GEITLER (1934, 1935) names this obscure mass nucleolar substance. CONARD (1931 a. b., 1933) says that this body consists of nucleolar substance and nuclear sap absorbed by nucleolus. Recently, MANTON (1935) observed the same body in the prochromosome nucleus of Cruciferae. The nucleolus and the body in question do not present nucleal-reaction. At the end of the prophase, chromosomes are gathered within and round this body.

3. Metaphase: In this stage, the nuclear membrane and the obscure mass disappear, and the number of chromosomes (at most twenty-four) corresponds to that of granules observed in the prophase. Chromosomes are buried in the filar cytoplasm, i e. the so-called spindle-substance (Fig. 7).

4. Anaphase: Each chromosome divides itself in half, and each piece migrates to two different poles to form a pair of compact masses there (Fig. 8, 9, 16).

5. Telophase: At the end of this stage, there appears round the group of chromosomes the nucleolar substance that does not show nucleal reaction (Fig. 10, 11, 17) from which the nucleolus is formed. At the same time, we can observe the chromatic granules distributed in the symmetrical position within the two daughter nuclei. The spindle substance remains to the last (Fig. 12, 18).

Discussion

PETTER (1933), SHINKE and SHIGENAGA (1933) and YAMAHA report the negative nucleal-reaction of the nucleus of *Spirogyra*. YAMAHA tried the staining with various duration of hydrolysis (from 4 to 10 minutes) and with the time of staining from 15 to 60 minutes; but he always observed negative reaction. GEITLER (1935) made observations with 6 to 8 minutes of hydrolysis and 2 to 3 hours of staining (He says that it is not necessary to wash the material with dilute sulphurous acid.); and he found positive reaction in three species and negative reaction in one (*S. fluviatilis*). We spent a little more time (namely, 3–4 hours) in staining than the previous authors. Having stained the material, we steeped it in the dilute sulphurous acid for 14–16 hours and washed away fuchsin-sulphurous acid completely. Undoubtedly, the duration of hydrolysis takes an important part in deciding whether the reaction should be positive or not (YAMAHA 1935). At the same time, the longer we stain the material, the more deeply it is stained (YAMAHA & SUEMATSU 1936). As the author also found in another species of *Spirogyra* nuclei that do not show nucleal-reaction, we can conclude that nuclei of some species of *Spirogyra* show nucleal-reaction while those of other species do not.

As is clear from what we explained above, the nucleus of *Spirogyra* resembles prochromosome nucleus (euchromocentric nucleus) of higher plants. Moreover, the karyotin granules observed in the prophase grow into chromosomes in the metaphase and anaphase, and show nucleal-reaction throughout the whole course of nuclear division. GEITLER says that the chromosomes do not show nucleal-reaction at the beginning of telophase when they are gathered in the nucleolar mass and cannot be clearly distinguished from one another. But the author observed nucleal-reaction of chromosomes even at this stage.

As to the origin of chromosome, MEUNIER (1888), TRÖNDLE (1911, 1912) and MCALLISTER (1931) report that the nucleolus itself grows into chromosome; but, from our observation, we do not think this supposition corresponds to the fact. GEITLER (1934, 1936), STOLLEY (1930) and CONARD (1931 a. b., 1933) believe that the chromosome appears in the nucleus independent of the nucleolus. We think that the prochromosome granules grow into chromosomes and again they resolve into chromatic granules in the telophase. Therefore, there is no difference between the nucleolus of *Spirogyra* and that of higher plants (plasmosome, nucleolus that does not contain chromatin) (TISCHLER, 1934 p. 89) Another thing that deserves our notice is that "nucleolar mass" is visible round the chromosome or the granules both in late prophase and early telophase, i. e. when the chromosome begins to appear and when it begins to disappear. CONARD says that this mass covers the chromosomes even in metaphase and that it takes an important rôle in the migration of the chromosomes towards the poles. Recently, MANTON found the same mass in Cruciferae and he thought that the substance consists of nucleolar substance and nuclear sap.

Conclusion

1. In the nuclei of three species of Japanese *Spirogyra*, we can observe chromatic granules and chromosomes showing nucleal-reaction.

2. The nucleus of *Spirogyra* seems to correspond to the prochromosome nucleus (euchromocentric n.) of higher plants. Therefore the nucleus of *Spirogyra* is of the same structure and substance as those of the nucleus of higher plants.

3. The number of the prochromosome observed in prophase corresponds to that of the chromosomes found in metaphase. The chromosome has its origin in prochromosome and the nucleolus has no direct connection with the formation of chromosome.

4. The nucleolus of *Spirogyra* is neither the reservoir of chromatin as ZACHARIAS supposed, nor is it what we call karyosome or amphinucleolus.

In conclusion the author wishes to express his sincere appreciation to Prof. G. YAMAHA for suggesting the problem and rendering valuable assistance during the course of this work.

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Explanation of Plate VIII

Figs. 1, 2. Resting nucleus with chromocenters.

Fig. 3. Early prophase.

Figs. 4, 5, 6. Prophase with an obscure body.

Fig. 7. Metaphase with 24 chromosomes.

Figs. 8, 9. Anaphase.

Figs. 10, 11. Early telophase, Fig. 11. An obscure body appearing.

Figs. 12, 13. Late telophase, w...cell wall newly formed. Chromocenters and nucleoli arranged symmetrically in both daughter nuclei.

Fig. 14. Resting nucleus with chromocenters.

Fig. 15. Early prophase.

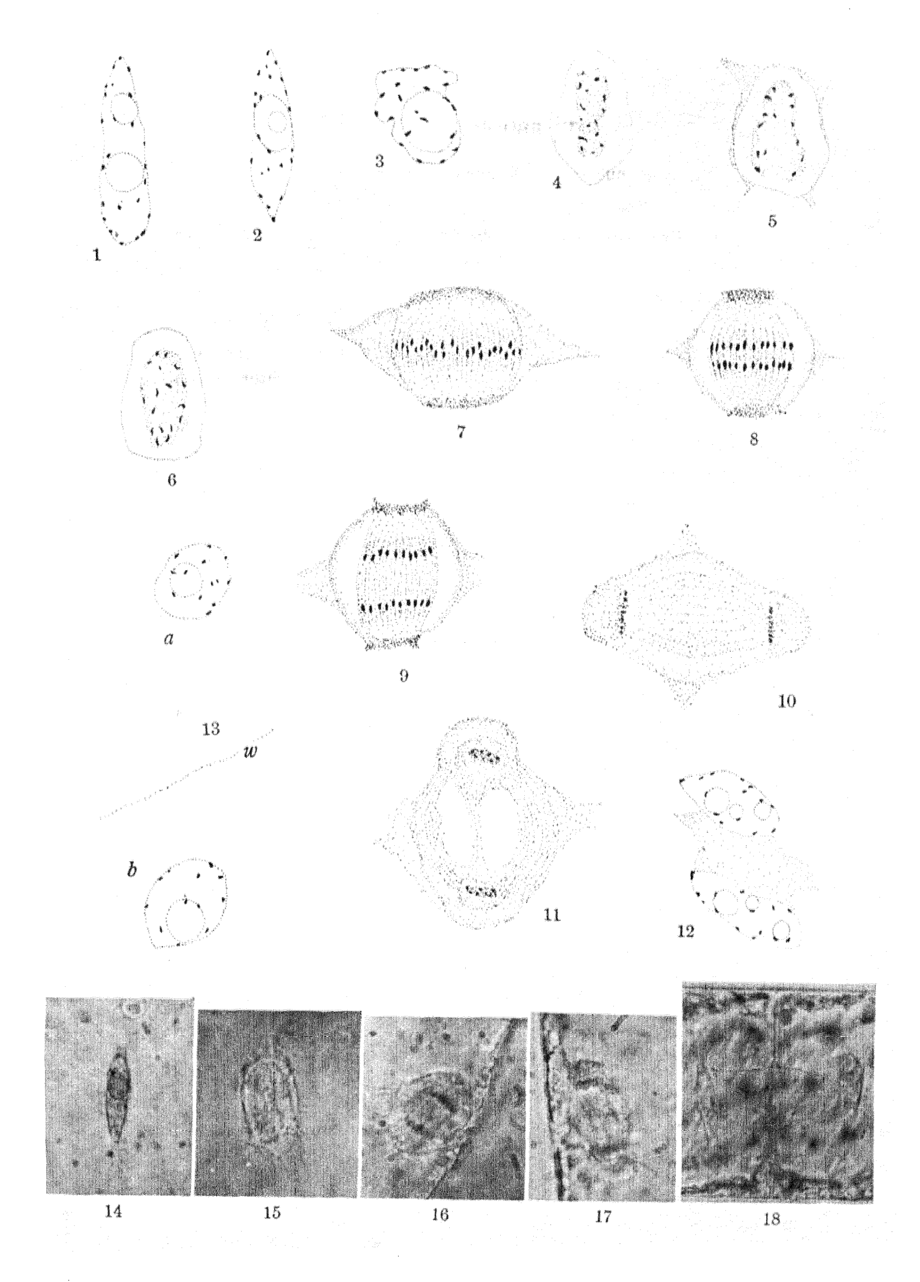
Fig. 16. Anaphase.

Figs. 17, 18. Telophase.

Magnification × 1350 (Figs. 1–13), × 520 (Figs. 14–18)

Figs. 1–17 are drawn or photographed from the material (*Spirogyra* A) fixed with 80% alcohol, stained with FEULGEN's fuchsin-sulphurous acid.

Fig. 18 is taken from the living material (*Spirogyra* B).



S. SUEMATSU: Karyological Study of *Spirogyra*

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OF THE

TOKYO BUNRIKA DAIGAKU

SECTION B

No. 48

ON THE NEUROMOTOR SYSTEM AND SOME OTHER MORPHOLOGICAL CHARACTERISTICS OF *PROTOOPALINA AXONUCLEATA LATA* METCALF

By

Y. HARA

Zoological Institute
TOKYO BUNRIKA DAIGAKU
(Tokyo University of Literature and Science)
KOISHIKAWA, TOKYO

December 14, 1936

NOTICE

The reports are published any time when received, about 300 pages thereof making up each volume.

All communications relating to these reports should be addressed to the chairman of the committee.

On the neuromotor system and some other morphological characteristics of *Protoopalina axonucleata lata* METCALF

By

YASUJI HARA

[With 14 Text-figures]

(Received November 6, 1936)

Many papers concerning *Opalina* and its relatives have hitherto been published by several authors, of which those by METCALF are especially important. The following note, which is a memorandum of my studies of this species during the past two years, is chiefly concerned with the neuromotor system. On publishing this, it is my pleasant duty to express my hearty thanks to Professor T. FUKUI for his kind advice and encouragement.

Method

This animalcule is found parasitic in the rectum of *Rana nigromaculata nigromaculata* HALLOWELL. For studying it I found the smear method to be most successful. No egg-albumen is placed on the slide, for fecal substances are sufficient to hold the animalcules in half dried state. The slides are then slowly put into the fixing fluid i.e. BOUIN's solution, and a modification of SCHAUDINN's fluid (acetic acid 10 cc, corrosive sublimate 100 cc, absolute alcohol 50 cc). The latter agent used at 60°C. gives the best result after 5 hours' immersion, and then the slides are impregnated with 1% iron alum for 2 minutes. 20 hours' immersion in 2% HEIDENHAIN's iron haematoxylin has given me the best staining. Differentiation is done under the microscope using acid alcohol. The sectioning method is employed to cut the animalcules, together with the rectum of the host. The centrifuging method is less adequate. The dyes used for staining are acid fuchsin, BISMARCK brown, methyl violet and methylen blue. For making clear the finest details of the structure the best result has been obtained by the use of HEIDENHAIN's iron haematoxylin followed by acid fuchsin.

Observation

This parasite is chiefly found in the upper part of the rectum of the host, and in general it makes masses between the contents and the rectal wall. When there are a great many of them, they are often found filling the upper portion of the rectum.

This parasite is generally found in company with some species of nemas, distomes, *Nycotherus*, *Balantidium* and flagellates. The frequency of infection is about 70%. If frogs are kept in starvation for 2 months, the parasite produces longitudinal ridges and becomes smaller in size.

There are two forms in *P. axonucleata lata* METCALF. One is almost cylindrical, the anterior end of the body being rounded and the posterior end slender (slender form). The length of the body is 140 μ and the width 30 μ. The other is broader with a slender posterior end (broad form), the length of the body being 140 μ and the width 50 μ.

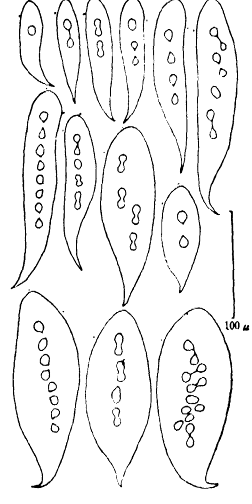


Fig. 1. *Protoopalina axonucleata lata* METCALF.
•····• morphological ant. end

In both forms the entire body is covered with a thin, elastic pellicle and shows no special characteristics.

The two basal cilia lines in both forms, extend from dorsum to venter on the anterior end of the body and the distance between these two cilia lines is the largest at the anterior end, almost approaching on both ventral and dorsal side.

The length of the morphological anterior end of the body is represented by the length of these basal cilia lines and it is longer in the broad form than in the slender one.

In both forms, the body cilia lines are arranged slightly oblique, or sometimes parallel to the longitudinal axis of the body. Longitudinal rows extend from the basal cilia line to the posterior end of the body, but the tail end is devoid of the cilia. All the longitudinal cilia lines are not of the same length, but some are interrupted at various places of the body. At the stage with two nuclei the secondary cilia lines develop between the primary cilia lines. They

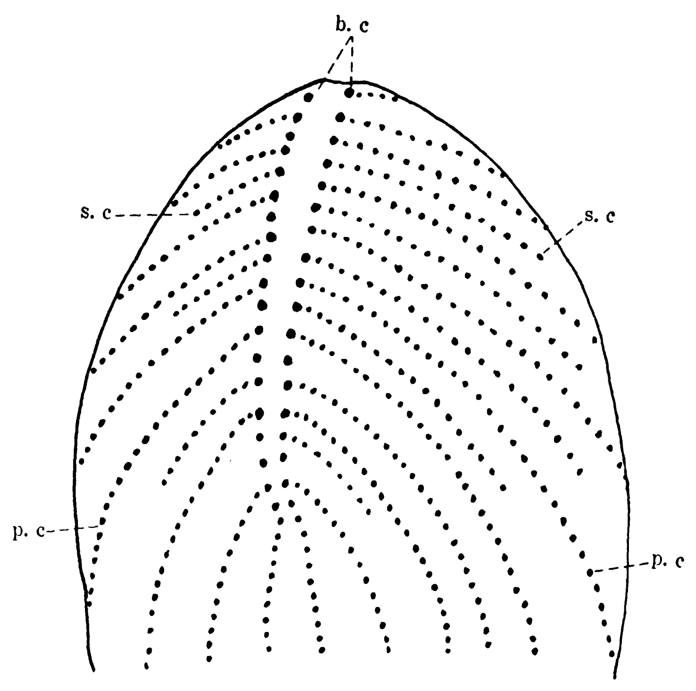


Fig. 2. Cilia lines at the anterior of the body
b. c basal cilia line. p. c primary cilia line. s. c secondary cilia line.

are much shorter than the latter. The number of rows varies from eight to ten in the two nuclei stage and 36 rows are found in the stage over four nuclei. The number of rows is counted at the middle part of the body, and it shows the total number on both sides. METCALF states, "In this species, as in most others, the main rows of cilia run the whole length of the body, but, anteriorly accessory rows are interpolated between the main rows, causing the cilia to be more numerous to the unit of width upon and near the front end of the body. In *Protoopalina intestinalis* the rows of cilia over the anterior quarter of the body three-quarters. In some other species the accessory rows of cilia, interpolated anteriorly, are still more numerous, the cilia rows in front being three times as close together as they are behind, or in a few species four times. In some species, on the other hand, the cilia rows are almost as closely placed behind as in front."

The main rows of cilia of METCALF correspond to my primary cilia line mentioned above and the accessory rows to my secondary ones, but the primary ones do not extend the whole length of the body as METCALF states.

The broad form has about 48 cilia lines. I found that the number of cilia lines was greater on the right side than on the left. The cilia are all in equal length. The measurement shows about 7 μ.

Ectosarc. The subpellicular layer which was first found by METCALF in *Opalina dimidiata* and others is not recognized in the present species.



Fig. 3. Concave portion of the pellicle at the anterior of the body.



Fig. 4. Endosarc spherules
left......slender form
right....broad form ×1500

The ectosarc spherules which were found in *O. intestinalis*, *O. caudata* by METCALF, are not recognizable in the slender form, but in the broad form small granules are scarcely found scattered in the middle portion of the body. The granules are stained black with HEIDENHAIN's iron haematoxylin followed by acid fuchsin.

At the anterior end of the body the pellicle is concave between the basal cilia lines, and the ectosarc there is somewhat thicker. Endosarc sometimes shows rough alveolar structure there, and contacts directly to the pellicle at the concave part in the over four nuclei stage, but such a structure is not found in the two nuclei stage.

Endosarc. Endosarc spherules are found denser in the middle portion of the body. In the slender form, they are spherical in shape and stained uniformly deep dark brownish with HEIDENHAIN's iron haematoxylin. But after proper destaining, the central portion of the larger spherules becomes so decolourized as rings.

In the broad form endosarc spherules are ovoid, spherical or conical in form and various in size. In this form they are densely scattered in the middle portion of the body. Usually, the shorter diameter of spherules is situated parallel to the longitudinal axis of the body in total preparation. The number of spherules in the broad form is less than that in the slender form. The diameter of the endosarc spherule in both form varies from 0.8 to 2 μ. I have never observed a case in which the endosarc spherules are dividing. No excretory organ is found. Sometimes, at the posterior end of the broad form, I find granules which are stained somewhat differently from the ordinary endosarc spherules. In the slender form, such granules are not recognized. METCALF (1909) recognized the existence of the excretory organ in three species of *Opalina* (*O. obtrigona*, *O. caudata*, and *O. intestinalis*), and he was inclined to believe that this organ was absent in the flattened form. The presence in the broad form and the absence in the slender form of these granules in *P. axonucleata lata* METCALF are perhaps to be regarded as the trace of the fiber at the excretory organ (fig. 6).

Nucleus. The number of the nucleus in one individual varies from one to thirteen in four hundred individuals observed (fig. 7). The half of the material is in the four nuclei stage. In the broad form their arrangement is irregular in the over eight nuclei stage, but not scattered in the whole body. The shape of the nucleus in both forms is spherical or ovoid. Measurement: length 7–15 μ, width 4.8—10 μ. One or both of the ends of the nucleus are generally pointed. Sometimes these pointed ends are connected with one another by a delicate strand consisting of the attenuated nuclear membrane.

METCALF states "In both the narrow and the broad forms of this species the macrochromosome number seems to be four." I agree with METCALF's observation on this point.

The nuclear membrane is persistent in all phases of the nuclear behavior, not disappearing even during mitosis.

Four macrochromosomes are lying just beneath the nuclear membrane. During the division the shape and size of the microchromosomes become very irregular (fig. 8).

Identification of the species

According to METCALF (1909) *P. axonucleata lata* METCALF is described as follows: "Measurements: A, of a small individual with

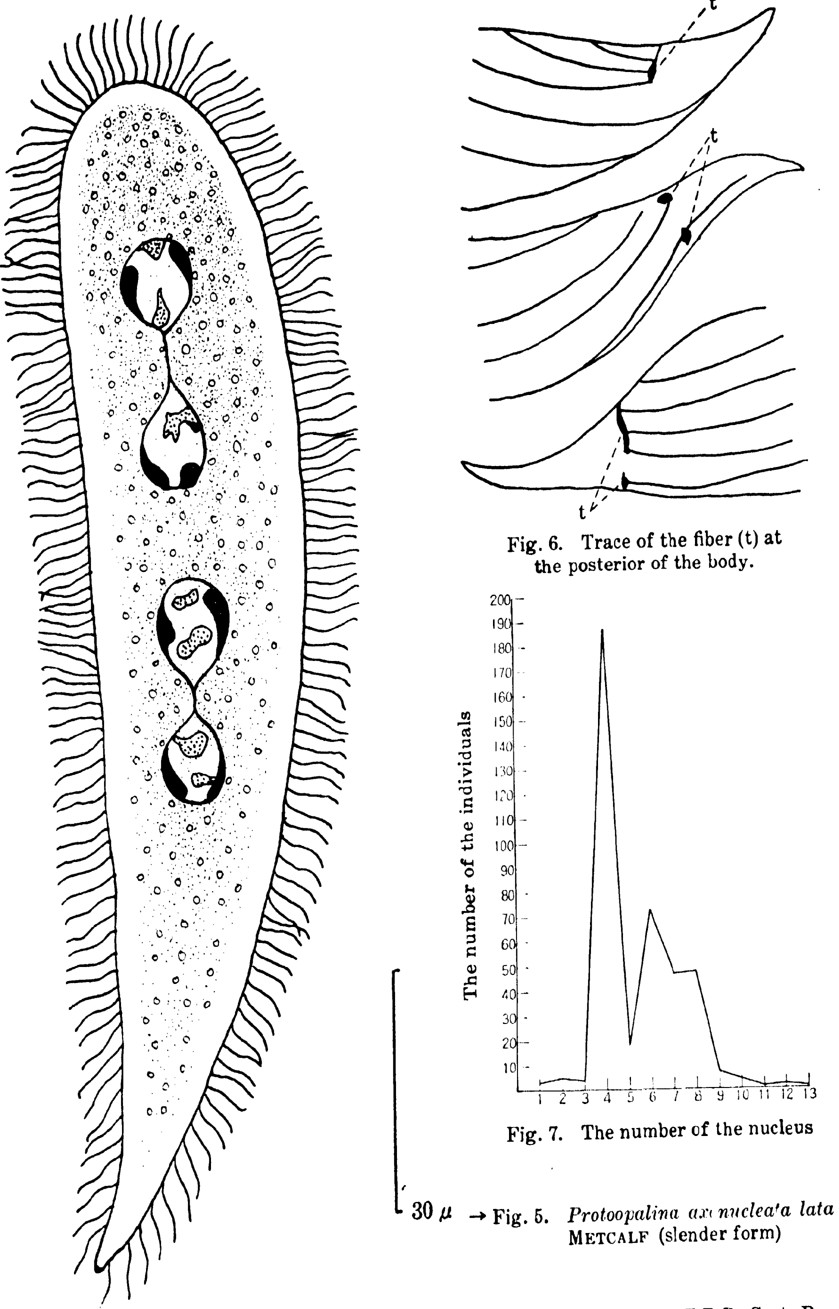


Fig. 6. Trace of the fiber (t) at the posterior of the body.

Fig. 7. The number of the nucleus

→ Fig. 5. *Protoopalina axonucleata lata* METCALF (slender form)

four nuclei; B, of a large individual with eight nuclei.

	A	B
Length of body	158.0	245.0
Width of body	39.0	51.0
Length of nucleus	10.0	12.0
Width of nucleus	6.5	6.5
Diameter of endospherule	2.0	2.0

There is in some individuals a wide round pointed, posterior process. In both the narrow and the broad forms of this species the macrochromosome number seems to be four".

In my observation, the species is found to be identical with *P. axonucleata lata* METCALF in the shape of the body, the relative size of the body, and the number of the nucleus. According to METCALF's observation, "A is a small individual with four nuclei and B is a large one with eight nuclei", but in the species concerned, there are stages from one nucleus to eight in the slender form and from one to thirteen in the broad form.

Neuromotor system. METCALF states "No nervous centers have been observed in connection with this network in any species of Opalinid". In *P. axonucleata lata* METCALF, the neuromotorium lies in the ectoplasm on the dorsal side and beneath the basal cilia line. It is intensively stained with iron haematoxylin. The left one of the basal fiber is more slender than the right. The distance of the two fibers is sometimes wide or narrow. I am inclined to think that the variability of the distance of the two fibers is due to the contraction or extention of the longitudinal fiber.

In the slender form, the longitudinal fibers arise at the basal fiber and its number is more on the right side than on the left. In the four nuclei stage, there are 24 rows at the middle part of the body. At this stage short longitudinal fibers arise at the basal fiber, especially at the right mortorium, and then, the number of the longitudinal fibers on the right side is much greater than on the left.

I should like to name the longitudinal fibers observable at the four nuclei stage "the primary and secondary longitudinal fibers". These secondary longitudinal fibers are irregular in growth, and unequal in length. The total number of these is about 36 at the middle part of the body.

In the broad form, the secondary longitudinal fibers grow longer than in the slender form, and the number of the fibers is about 48.

The earlier stage of the secondary longitudinal fiber is very

slender, but it grows continually and becomes longer and thicker. This is to become the primary one, reaching almost the same length and thickness.

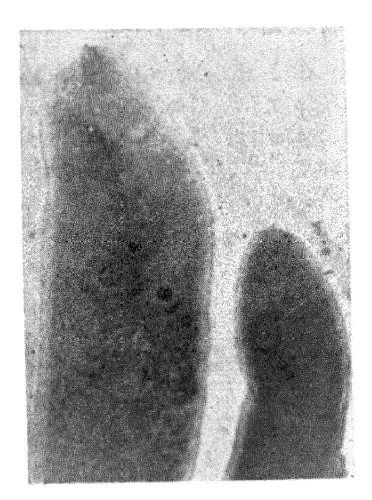


Fig. 11. Photograph showing basal fiber.

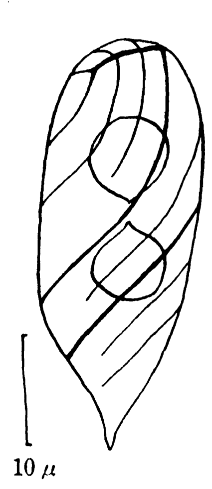


Fig. 12. Neuromotor system at two nuclei stage (broad form).

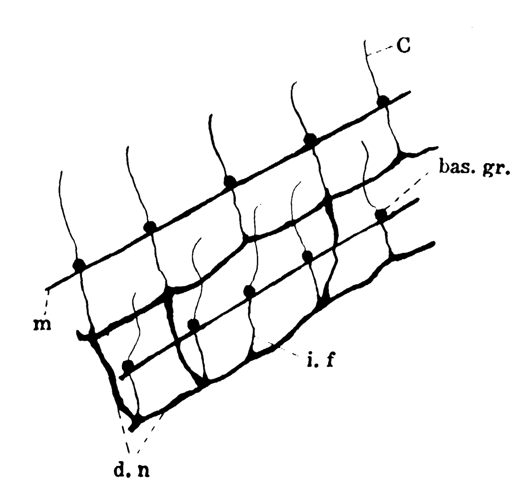


Fig. 13. A part of the body surface (schematic)
m...longitudinal fiber C...cilia d. n...deeper fiber net
i. f...inner fiber bas. gr...basal granule

Both fibers are thicker anteriorly and attenuated posteriorly. Three or four strands extend to the tail of the body in the slender form but no strand is found at the extreme end of the body. In the broad form, most of the longitudinal fibers decrease at the beginning of the tail, and four or five are to be seen at the tail.

The inner fiber is an exceedingly delicate thread which connects the basal granule to the deeper fiber net. The former becomes gradually thicker at the end of the ectosarc. The deeper fiber net is found anastomose on the surface and the interior of the endosarc.

In *P. intestinalis*, METCALF states as follows: "The basal granules in each longitudinal row are united by an extremely delicate longitudinal thread (longitudinal fiber). Similarly the basal granules of adjacent rows seem to be connected transversely by very delicate fibrillae, though the appearance is more vague and less sharply defined...., the transverse fibrils of this network lie beneath and

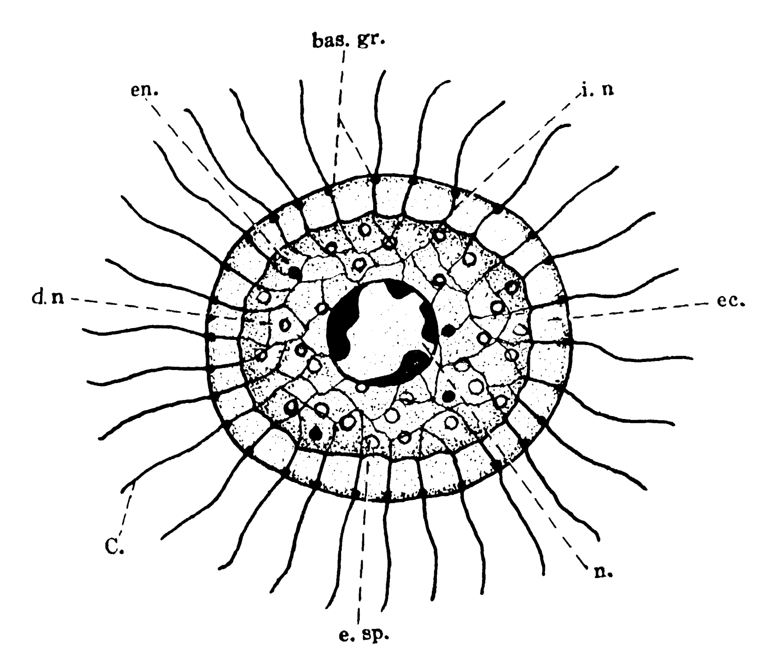


Fig. 14. Transverse section

bas. gr. basal granule C.′ cilia d. n deeper fiber net
ec. ectosarc en. endosarc e. sp endosarc spherule
i. n inner fiber

not in the pellicula, as accurate focussing clearly shows." I was able to confirm this observation of METCALF.

The basal granules rest directly on each fiber. METCALF states "The longitudinal fibrils are a little more superficial, lying apparently at the level of the outer ends of the basal granules". In my materials, longitudinal fibers do not lie at the level of the outer ends of the basal granules. The basal fiber is set with large basal granules of cilia, while the anterior part of the longitudinal fiber is closely set with somewhat smaller ones. Along the rest of the longitudinal fibers, they are placed quite evenly and equidistant until they gradually become somewhat larger and unequidistant as the fibers approach the free end. I have observed that two or three of the basal granules are not resting on the longitudinal fiber at the free end of the cilia line. Large basal granules of cilia are found situated at the mortorium in the two nuclei stage.

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TOKYO BUNRIKA DAIGAKU

SECTION B

No. 49

BRYOZOA FAUNA COLLECTED BY THE "MISAGO" DURING THE ZOOLOGICAL SURVEY AROUND IZU PENINSULA (II)

By

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KOISHIKAWA, TOKYO

December 16, 1936

NOTICE

The reports are published any time when received, about 300 pages thereof making up each volume.

All communications relating to these reports should be addressed to the chairman of the committee.

Bryozoa Fauna collected by the "Misago" during the Zoological Survey around Izu Peninsula (II)[1]

By

Y. OKADA and SH. MAWATARI

[With Plates IX—X]

(Received Nov. 28, 1936)

This is the second paper on the Bryozoa fauna around Izu peninsula. We have already published the first paper in the last year dealing with the collection of 1934, and in the present paper mainly we describe the specimens collected on June, 1935, including 17 genera and 24 species, of which 6 species seem to be new to science.

Order CHEILOSTOMATA BUSK

Suborder *Anasca* LEVINSEN 1909

Division *Malacostega* LEVINSEN 1909

Family Flustridae SMITT 1867

Genus *Spiralaria* BUSK 1861

1. *Spiralaria spinuligera* HINCKS 1882.

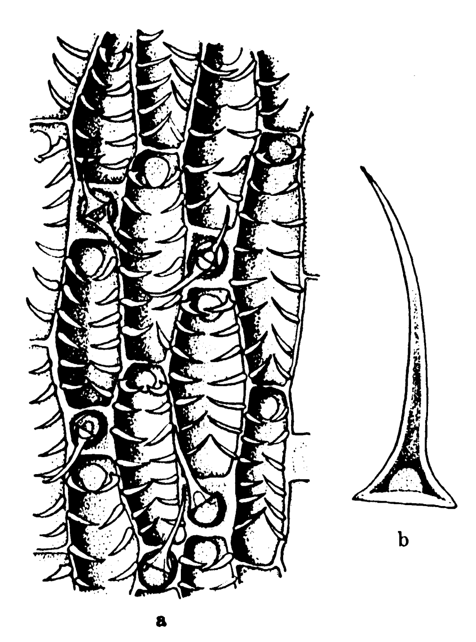
(Plate IX, fig. 7, Text-fig. 1.)

Spiralaria spinuligera MARCUS 1926, Tierwelt d. Nord- und Ostsee, 7c, p. 71, text-fig. 48.—CANU & BASSLER 1929, U. S. N. M., Bull. 100, p. 92, fig. 22, J. K.

Diagnosis: The zoarium incrusts sponges, flat, unilamellar. The zooecia are distinct, elongated, rectangular or hexagonal, arranged in numerous linear series alternately. The front wall is entirely membranous, and the remaining part is poorely calcified, semi-soft. The mural rim is salient, more or less thickened, ornamented by 6–8 pairs of short marginal spines, and of which the distal

1) Contributions from the Shimoda Marine Biological Station, Tokyo Bunrika Daigaku, No. 20.

pair is usually larger and serrate or bifurcated. The opecium is regular, round or oval. The avicularia are quite interzooecial, forming the quadrate peculiar chambers between zooecia; the mandibles are elongated, slender, pointed obliquely at the end. The ooecia unknown.



Text-fig. 1. *Spiralaria spinuligera* HINCKS.
a. Zooecia.
b. Mandible of avicularium.

Locality: A large complete colony was obtained at a station between Hatsushima and Itô.

Family *Alderinidae* CANU & BASSLER 1927

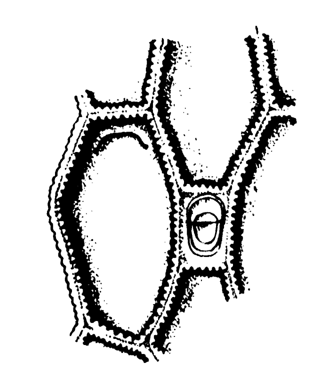
Genus *Ellisina* NORMAN 1903

2. *Ellisina crenulata* OKADA 1929.

(Text-fig. 2.)

Ellisina crenulata OKADA, 1929, Sci. Rep. Tōhoku Imp. Univ., Biol., vol. 4, no. 1, p. 12, pl. 4, fig. 1.

Diagnosis: The incrusting zoarium is flat, consisting of many linear series of zooecia. Zooecia are distinct, subhexagonal or rectangular, somewhat thickly calcified, separated by salient walls. The frontal is quite membranous; the inner margin of zooecial wall is strongly serrated. The avicularia are situated in the chambers scattered among zooecia, with semicircular mandibles pointing obliquely downwards. The opecium is normal, elliptical. The ooecia are unknown.



Text-fig. 2. *Ellisina crenulata* OKADA

Zooecia with an interzooecial avicularium.

Distribution: Mutsu Bay, Aomori-ken, Japan.

Locality: A small fragment was obtained at a station between Hatsushima and Itô.

Note: The present specimen is closely allied to *Ellisinidra pyriformis* CANU & BASSLER, but differs from it in the shape of avicularia and with the crenulated inner margin of zooecium.

Division *Cellularina* SMITT 1867

Family *Scrupocellariidae* LEVINSEN 1909

Genus *Scrupocellaria* VAN BENEDEN 1845

3. *Scrupocellaria diadema* BUSK 1852.

Scrupocellaria diadema BUSK, 1852, Poly. Sert. Zoophy. Voy. Rattlesnake Aust. & Louis. Arch., p. 370.—BUSK, 1852, Cat. Mar. Poly. Brit. Mus.. 1, p. 24, pl. 28, figs. 1–3.—HASWELL, 1880, Proc. Linn. Soc. N. W. Wales, p. 37.—HINCKS, 1884, Ann. Mag. Nat. Hist., 5, 13, p. 357.—HINCKS, 1887, Journ. Linn. Soc. Lond., 21, p. 129, pl. 12, fig. 6.—ORTMANN, 1890, Arch. f. Naturg., 56, 1, p. 22, pl. 1, figs. 4 a–c.—KIRKPATRICK, 1890, Sci. Proc. R. Dublin Soc. (N. S.), 6, p. 603. —THORNELY, 1905, Rep. Oys. Fish., p. 109.—THORNELY, 1907, Rec. Ind. Mus., 1, p. 181.—YANAGI & OKADA, 1918, Annot. Zool. Jap., 9, p. 414.—MARCUS, 1921, K. Svensk. Vet-Akad. Handl. Stockholm, 61, 5, p. 6, pl. 1, fig. 1.—MARCUS, 1922, Abhandl., pl. 24, fig. 2.—OKADA, 1923, Annot. Zool. Jap., vol. 10, art. 22. p. 221.—HARMER, 1926, Siboga Exped., 28, b, pp. 375–378, pl. 25, figs. 20–25.—OKADA, 1934, Sci. Rep. T. B. D. sect., B. vol. 2, p. 6.

Scrupocellaria cervicornis BUSK, 1852, Cat. Mar. Poly. Brit. Mus., p. 24, pl. 62, figs. 1–4.

Scrupocellaria annectens MACGILLIVRAY, 1887, Trans. Roy. Soc. Vict., vol. 23, p. 184, pl. 1, figs. 11, 1a.

Scrupocellaria gaspari THORNELY, 1907, Rec. Ind. Mus., 1, p. 181, textfig.

Scrupocellaria jolloisii ROBERTSON, 1921, Rec. Ind. Mus., 22, pt. 1, no. 8, p. 36.

Diagnosis: The zoarium articulated, dichotomous; the joint transversing the middle of the opecia of the outer zooecium. The zooecia are distinct; the opecia often occupying about two-thirds of the front; the mural rim is thick; the scutum typically present, variable in shape, not filling the opecia, sometimes wanting. The oral spines are slender, typical, 5 in number, 2 external, 1 distal, 2 internal. The frontal avicularia usually present, compressed and raised, with triangular mandibles. Axillary zooecium bears commonly a large frontal avicularium with the rostrum denticulated, and with the elongate triangular mandibles. The marginal avicularia are small. The seta are long, the setal groove oblique, the rootlet-foramen lateral. A single vibraculum is in the axil. Ooecia are very short, with large pores.

Distribution: Queensland; Torres-Strait; Society Islands; Malay Peninsula; Aru Islands; Java; New Guinea; Sumatra; Singapore; Andaman Islands; off Burma (69–80 m.); Madras (6–10 m.); Ganjam coast (38–48 m.); Ceylon; Philippine (57 fms.); Japan—Tsushima Channel (97–175 m.); Shimoda, Shizuoka-ken.

Localities: Several fragments were collected at three stations off Manazuru, off Fukuura, and between Hatsushima and Itô.

Genus *Canda* LAMOUROUX 1816

4. *Canda retiformis* POURTALES 1867.

Canda retiformis POURTALES 1867, Bull. Mus. Comp. Zool. Harvard Coll., 1, No. 6, p. 110.—PHILIPPS, 1899, Rep. on Poly., Willey, Zool. Results, pt. 4, p. 441, pl. 42, fig. 1.—WATERS, 1913, Proc. Zool. Soc. London, p. 479, pl. 69, figs. 1, 2, 6.—OSBURN, 1914, Publ. Carn. Inst., no. 182, p. 192.—CANU & BASSLER, 1929, Bull. 100, U. S. N. Mus., vol. 9, pl. 212.—THORNELY, 1912, Trans. Linn. Soc. Zool., vol. 15, p. 141.

Caberea retiformis SMITT, 1872, Florid. Bry. Kongl. Svenska Ventens. Handl., vol. 10, no. 11, p. 16, pl. 5, figs. 43–46.—THORNELY, 1905, Ceylon Pearl-Oyster Fisheries, vol. 4, Suppl. Rep., 26, p. 109.

Diagnosis: The zoarium is formed of rectilinear segments, dichotomous, without apparent articulation. The zooecia are distinct,

rectangular. Avicularian chamber is wide, and the mandible is triangular. Two vibracula at a bifurcation. Near the base of the vibracular seta there is a projecting delicate free arch at right angles to the axis of the seta.

Distribution: Philippine; Gulf of Mexico; Florida; Zanzibar Channel.

Locality: A small fragment which may be identified with this species, was obtained at a spot off Manazuru-saki.

Genus *Menipea* LAMOUROUX 1812

5. *Menipea occidentalis* TRASK 1857.

Menipea occidentalis TRASK, 1857, Proc. Cal. Acad. Sci., p. 113, pl. 4, fig. 4.—ROBERTSON, 1905, Univ. Calif. Publ. Zool., vol. 2, p. 254, pl. 6, figs. 22–25.—OKADA, 1918, Annot. Zool. Jap., vol. 9, part 4, p. 409.

Menipea compacta HINCKS, 1882, Ann. Mag. Nat. Hist., 5, 10, p. 461.—HINCKS, 1884, Ann. Mag. Nat. Hist., 5, 13, p. 208, pl. 9, fig. 8.

Diagnosis: The zoarium is articulated and biserial, forming a bushy tuft attached to the sea-weed; the branching is regular and each segment has usually 3–6 zooecia. The zooecia are elongated, and narrowed proximally; the aperture is oval or elliptical occupying about half the gymnocyst, surrounded distally by six jointed spines usually, some of which are bifurcated, covering the large part of the aperture. The lateral avicularia are very well developed, the frontal avicularia are small and rare. The radicular dietella is placed on the proximal portion of the external zooecium below the chitinous tube. The ooecia are large, globose, hyperstomial, perforated by a small number of pores.

Distribution: Japan—Misaki, Yokohama, Kanagawa-ken; Ozu, Ibaraki-ken.

Localities: Several complete colonies were obtained at the two stations, off Fukuura and between Hatsushima and Itô.

Family *Beaniidae* CANU & BASSLER 1927

Genus *Beania* JOHNSTON 1847

Subgenus *Diachoris* BUSK 1852

6. *Beania (Diachoris) discodermiae* ORTMANN 1890.

Diachoris discodermiae ORTMANN, 1890, Arch. f. Naturg., Jahrg. Bd. 1. p. 26, pl. 1, fig. 23.

Beania discodermiae HARMER, 1926, Siboga Expeditie 28 a, p. 415, pl. 28, figs. 9–10.

Diagnosis: The zoarium is free, attaching to the substratum, soft, flat, multiserial, reticulate; the fenestrae moderate but narrower than the zooecia. The zooecia are little calcified, elliptical, elongated, suddenly narrowed in the distal one-third of the length, longitudinal, and are joined together by six stoloniform prolongations, the connecting tubes, one from the proximal, and the other four from the lateral walls of the zooecia. The mural rim of the zooecia bears 5–11 long, slender marginal spines on one side and 3–4 shorter distal spinules. The avicularium is large pedunculate, with a globose head not compressed, and narrow, with a symmetrical rostrum, situated on either distal side of the zooecium, just on the proximal side of the operculum, with long slender, slightly curved mandibles. Ooecium is vestigial.

Locality: One small fragment of a colony was obtained at a spot off Manazuru.

Note: The present species differs from *Diachoris distans* HINCKS in zooecial features and in having the many marginal spines, distal spinules and long slender avicularia.

Suborder *Ascophora* LEVINSEN 1909

Family *Petraliidae* LEVINSEN 1909

Genus *Petralia* MAC GILLIVRAY 1887

7. *Petralia japonica* (BUSK) 1884.

(Plate IX, fig. 2.)

Lepralia japonica BUSK, 1884, Chall. Rep., p. 143, pl. 18, fig. 5.—WATERS, 1876, Suppl. Chall. Rep., 5, 31, pp. 1–41, pls. 1–3.—ORTMANN, 1890, Arch. f. Naturg., 5, 56, 1, p. 39, pl. 1, fig. 11.—WATERS, 1909, Journ. Linn. Soc., Zool., vol. 31, p. 149, pl. 13, figs. 10–12.—LEVINSEN, 1909, Morph. Syst. Stud. Cheil. Bry., pp. 352–353, pl. 13, figs. 5 a–b.

Petralia japonica MARCUS, 1921, Kungl. Svenska. Vetens. Ak. Hand., vol. 61, no. 5, p. 26, pl. 2, figs. 16, 17, pl. 2, fig. 3.—CANU & BASSLER, 1929, Bull. U. S. N. M., no. 100, vol. 9, pp. 254, 255, fig. 104.—WATERS, 1913, Proc. Zool. Soc. London, p. 518.—OKADA, 1934, Sci. Rep. T. B. D., sect. B, no. 26, p. 12.

Diagnosis: The zoarium is thick, unilamellar, covered with yellowish-brown epithelium. The zooecia are distinct, separated by

a furrow, pyriform, truncate below; the frontal is slightly convex or tumid, perforated by somewhat numerous, large tremopores. The aperture is large, slightly concave proximally and laterally, provided with thick peristome, having an operculum well chitinized marginally. The ooecium appears very seldom, deeply imbedded in distal zooecium, and is formed of porous cryptocyst. The lateral avicularium is small, circular or oval, almost entirely immersed, placed on one side of the aperture; the mandible is broadly rounded, as a rule, directed obliquely outwards and proximally.

Distribution: China Sea (88 fms.); Sibutu Island (175 fms.) Borneo; Indian Ocean; Mauritius; Trincomalee; Gulf of Manaar; Natal; Wasin (10 fms.); British East Africa; Red Sea; Bay of Agig Suraza (9 fms.); Japan—Sagami-Bay, Misaki, Enoshima, Kanagawa-ken; Shimoda, Shizuoka-ken; Hamajima, Mieken; Maizuru (35–40 fms.), Kyôto-fu; Kôbe (8–50 fms.), Hyôgo-ken; Okino-shima, Shimane-ken; Takanoshima, Chiba-ken; Formosa Channel (270 m.).

Locality: A small fragment was obtained at a spot off Hatsushima, 25–30 fms.

Genus *Petraliella* CANU & BASSLER 1927

8. *Petraliella armata* WATERS 1913.

(Plate IX, figs. 5, 6.)

Petraliella vultur var. *armata* WATERS, 1913, Proc. Zool. Soc. London, p. 618, pl. 70, figs. 15–20.

Petraliella armata CANU & BASSLER, 1929, U. S. N. M., Bull. 100, vol. 9, pp. 260–261, pl. 25, figs. 1, 2.—OKADA, 1934, Sc. Rep. T. B. D., Sect. B, vol. 2, no. 26, p. 14, pl. 2, fig. 5.

Diagnosis: The zoarium incrusts the substratum, unilamellar, flat, somewhat thick, faintly yellowish-brown in alcohol. The zooecia are distinct, separated by a salient thread all round, large, elliptical or rectangular, a little enlarged distally; the frontal is convex, perforated with many large tremopores, and the marginal series of pores are larger than the other and often two or three of them unite to form a single elliptical opening. The zooecial aperture is very large, semicircular, transverse; the proximal border is straight and bears a broad, median pseudolyrula and two salient, equal cardelles, limiting two small lateral indentations. The peristome is thin and little salient; the shield around the aperture is enlarged and rounded

laterally, supporting two round, a little elevated oral avicularia with semicircular mandibles on both sides. A large, non-striated, dissymmetric avicularian umbo is placed just before the aperture; a raised oval, oblique avicularium with a triangular, somewhat falciform mandible is on the top of it. One small, oval sporadic avicularium appears usually near the proximal part of the frontal. On the inferior side of each zooecium there is a radicular pore, rather constant in size, frequently closed by a chitinous pellicule. The ooecium is hyperstomial, broad, globular, halfly imbedded in distal zooecium, surrounded by very salient thread, finely perforated by numerous minute pores.

Localities: Two large colonies were collected at two spots off Hatsushima and off Manazuru-saki.

Note: In the zooecial aspects, the present specimen is closely allied to original species of *Petraliella armata* WATERS and *Petraliella philippinensis* CANU & BASSLER, but differs from the former in lacking a large avicularium and in having the non-striated avicularian umbo, and from the latter in the presence of salient threads surrounding both the zooecia and the ooecia, in the regular form of lateral indentations, in the absence of a large oblique avicularium, in the ooecium not burried in the distal zooecium, and in one radicular pore.

9. *Petraliella umbonata* n. sp.

(Plate IX, figs. 3, 4.)

Diagnosis: The zoarium is leaf-like or lanceolate, slightly thin and somewhat semi-transparent in the fringe, attaching to the substratum with the proximal end. The zooecia are distinct, elliptical, elongated, separated by deep furrow, arranged alternately in some linear series starting from the proximal end of the zoarium. The frontal is conspicuously convex, perforated by many wide tremopores, somewhat reticular in appearance, and minutely granulated. The shield-like area around the aperture is thin distally and thickened proximally; the small oral avicularium is absent but occasionally one or two avicularia with semicircular mandibles are present on the side of the aperture. The median avicularian umbo, situated just in front of the aperture is very distinct, dissymmetrically bifurcated at the base, having an oblique triangular mandible on the

inner-side. The umbo is conspicuously long, consisting of a striated, hollow process slightly curved outwards at the end. The zooecial aperture is semicircular, with thin peristome; the proximal margin is straight, having two, small, circular indentations laterally limited by the broad median pseudolyrula and two lateral condyles. The ooecia are unknown.

Locality: A single complete colony attached to a shell was obtained at a spot off Hatsushima.

Note: In general features, the present species is very similar to *Petraliella philippinensis* CANU & BASSLER, but may be easily distinguished from it in its highly projecting avicularian umbo.

Family *Stomachetosellidae* CANU & BASSLER 1920

Genus *Escharoides* MILNE-EDWARDS 1820

10. *Escharoides ramulosum* n. sp.

(Plate IX, fig. 8.)

Diagnosis: The zoarium is free, erect, cylindrical, bifurcated, formed of 4–5 longitudinal series of zooecia, arranged alternately. The zooecia are large, distinct, elongated, cylindrical, aliform distally, separated by salient furrows; the distal portion is terminated by a salient and almost complete peristomice with a large, developed oral mucro hiding entirely the aperture. The frontal is very convex, formed of a minutely granulated pleurocyst, bordered by numerous areolar pores which separate very short costules. The zooecial aperture is oval or circular. On each side of the peristomice there is large, transverse, spatulated, oral avicularium with pivot on the top of the elevated avicularian mucro. The ooecia unknown.

Locality: Small fragments were collected at a spot off Manazuru.

Note: The present species is close to *Escharoides erecta* CANU & BASSLER but differs from it in having the more prominent, broader, median oral mucro and in having the laterally situated avicularian mucro with a large spatulated avicularium.

Family *Escharellidae* LEVINSEN 1909

Subfamily *Schizoporellae* CANU & BASSLER 1917

Genus *Arthropoma* LEVINSEN 1909

11. *Arthropoma cecilii* (SAVIGNY-AUDOUIN) 1826.

Flustra cecilii, AUDOUIN, 1826, Expl., 1, p. 239.

Schizoporella cecilii HINCKS, 1880, Hist. Brit. Mar. Poly., p. 269, pl. 43, fig. 6.—MACGILLIVRAY, 1895, Trans. Roy. Soc. Vict., vol. 4, p. 33, pl. 11, fig.—ROBERTSON, 1908, Univ. Calif. Pub. Zool., vol. 4, no. 5, p. 288, pl. 19, fig. 43.—OKADA, 1923, Annot. Zool. Jap., vol. 10, art. 22, p. 229.—ORTMANN, 1890, Arch. für Naturg., vol. 50, p. 51, pl. 1, fig. 4.—CALVET, 1907, Exp. Scient. Trav. et Talism., p. 415.—THORNELY, 1910, Trans. Linn. Soc. Zoology, vol. 15, p. 147.

Arthropoma cecilii LEVINSEN, 1909, Morph. Stud. Chilost. Bry., p. 232.—WATERS, 1913, P. Z. S. Lond., p. 508.—WATERS, 1918, Journ. Linn. Soc. Zool., vol. 34, p. 20.—CANU & BASSLER, 1929, Bull. 100. U. S. N. M., vol. 9, pp. 296–297.

Diagnosis: The zoarium is incrusting, unilamellar, forming a circular expansion; the zooecia arranging radially and alternately, are very distinct, somewhat regularly hexagonal, globular, separated by a salient thread; the frontal is a tremocyst prominently convex, with a mucro just below the aperture and perforated by numerous large pores all over the surface, forming a reticulation. The aperture semicircular, with a straight lower margin, provided with a prominent linear rimule on the middle. The peristome thick, with a flat shield-like area perforated with a linear small pores along the upper margin and provided with a slightly projected umbo on the median of the lower margin just below the rimule. The avicularia are absent. Ooecia globose distinctly projected from the surface with nodulous surface, perforated with minute pores.

Distribution: Western Atlantic; British Channel; Gulf of Cadiz; Cape Blanc; Cape Verde; Mediterranean; Galapagos; La Jolla; California; Queen Charlotte Islands; Australia; China Sea; Indian Ocean; Reunion Island; Zanzibar Channel; Japan—Takanoshima, Chiba-ken; Okinose, Sagami Bay (300–400 fms.), Kanagawa-ken; Kagoshima Bay, Kagoshima-ken; Tsushima Channel, Yamaguchi-ken.

Locality: A complete colony was obtained at a spot off Hatsushima.

Note: The present specimen has very larger tremopores than the normal form.

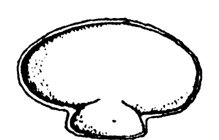
Genus *Dakaria* JULLIEN 1903

12. *Dakaria bidentata* (ORTMANN) 1890.

(Plate IX, fig. 1, Text-fig. 3.)

Lepralia bidentata ORTMANN, 1890, Arch. f. Naturg., 56, 1, p. 40, pl. 3, fig. 10.

Diagnosis: The zoarium is thin, unilamellar, incrusting sea-weeds, dark purplish brown in alcohol. The zooecia are distinct, elongated, elliptical, somewhat widened distally, arranged in linear series alternately, and clearly separated by a salient thread. The frontal is convex, finely perforated by many tremopores, each with more or less prominent, elevated margin. The aperture is semi-circular, with two large lateral condyles limiting a broad, characteristic, rectangular median rimule; the proximal margin of the rimule is straight or little convex. The peristome is entire, rather thin, salient, smooth or minutely granulated, with deep brown fringed operculum. No avicularia. The ooecia are unknown.



Text-fig. 3. *Dakaria bidentata* (ORTMANN). Operculum.

Distribution: Japan—Sagami-Bay (40 fms.), Kanagawa-ken.

Localities: Several complete colonies attached to sea-weeds were obtained at spots off Manazuru and Manazuru-saki.

Note: The present species is very resemble *Dakaria grandis* CANU & BASSLER, but differs from it in the presence of salient thread, broader aperture, and somewhat rectangular large rimule.

Subfamily Microporellae CANU & BASSLER 1917

Genus *Microporella* HINCKS 1877

13. *Microporella ciliata* (PALLAS) 1766.

Eschara ciliata var. B PALLAS, 1766, Elench. Zooph., p. 38.

Cellepora ciliata LINNAEUS, 1766, Syst. Nat., ed. 12, p. 1286.

Lepralia ciliata JOHNSTON, 1847, Brit. Zooph., ed. 2, p. 323, pl. 57, figs. 4, 5. —BUSK, 1854, Cat. Mar. Poly. Brit. Mus., 2, p. 73, pl. 74, figs. 1, 2, pl. 77, figs. 3–5.—BUSK, 1859, Crag. Pol., p. 42, pl. 7, fig. 6.

Microporella ciliata HINCKS, 1880, Hist. Brit. Mar. Poly., pp. 206–210, pl. 28, figs. 1–8.—OSBURN, 1912, Bull. Bur. Fish., vol. 30, pp. 233–234, pl. 24, figs. 44–44c.—NORDGARD, 1918, Bry. Arct. Reg., pp. 59–60.—WATERS, 1918, Journ. Linn. Soc. Lond., vol. 34, p. 26.—OKADA, 1923, Annot. Zool. Jap., vol. 10, p. 227.—CANU & BASSLER, 1923, Bull. 125, U. S. N. M., p. 119, pl. 20, figs. 1–6; pl. 36, figs. 4, 5.—OKADA, 1929, Sci. Rep. Tōhoku Imp. Univ., Biol., vol. 4, no. 1, fasc. 1, pp. 26–27, pl. 2, fig. 5, text-fig. 11.—CANU & BASSLER, 1929, Bull. 100, U. S. N. M., vol. 9, p. 331, pl. 40, figs. 2–4.—OKADA, 1934, Sci. Rep. T. B. D., sect. B. vol. 2, pl. 13.

Microporella vibraculifera HINCKS, 1883, Ann. Mag. Nat. Hist., 5, 11, p. 443, pl. 17, fig. 2.

Diagnosis: The zoarium incrusting shells is thin, unilamellar. The zooecia are distinct, arranged in radial lines, ovate; obscurely hexagosal, separated by deep furrows; the frontal is convex, punctate or granular. The aperture is semicircular with the straight proximal margin; the peristome is not salient and bears 5–7 spines. The ascopore is found little below the aperture, lunate, frequently on a small mucro. The frontal avicularium is on one side or the other, with an acute mandible directed obliquely upwards or laterally, sometimes vibraculoid. The ooecia are globose, areolated round the base, minutely punctured, with 2 spines distally.

Distribution: Cosmopolitan: Japan—Okinosé, Jôgashima, Misaki, Kanagawa-ken; Gotô Is., Nagasaki-ken; Ushijima, Yamaguchi-ken; Chôsi, Tateyama, Chiba-ken; Takashima, Wakkanai, Hokkaido; Kurokutô, Yamagata-ken; Kushimoto, Wakayama-ken; Yakushima, Kagoshima-ken; Misaki, Ehime-ken; Shimoda, Shizuoka-ken.

Localities: Several complete colonies attached to the shells of *Laqueus* sp. were obtained at two spots between Hatsushima and Itô.

Family Smittinidae LEVINSEN 1909

Genus *Smittina* NORMAN 1903

14. *Smittina reticulata* (MACGILLIVRAY) 1842.

Lepralia reticulata MACGILLIVRAY, 1842, Ann. Mag. Nat. Hist., 9, p. 467. —JOHNSTON, 1847, Brit. Zooph., ed. 2, p. 317, pl. 55, fig. 10.—BUSK, 1854, Cat. Mar. Poly. Brit. Mus., 2, p. 66, pl. 90, fig. 1, pl. 92, figs. 1, 2.

Smittina reticulata HINCKS, 1880, Hist. Brit. Mar. Poly., pp. 346–348, pl. 48, figs. 1–5.—JELLY, 1889, Synon. Cat. Mar. Bry., p. 250.—MACGILLIVRAY, 1895, Trans. Roy. Soc. Vict., vol. 4, p. 93, pl. 12, figs. 20–21.—CALVET, 1907, Camp. Travail. Talism., p. 432.—ROBERTSON, 1908, Univ. Calif. Publ., vol. 4,

p. 308, pl. 23, figs. 75, 76.—NORDGARD, 1918, Bry. Arct. Reg., p. 60.—NORDGARD, 1900, Den. Nors. Nordh.-Exp., 27, p. 13.—CANU & BASSLER, 1928, Mem. Soc. Sci. Nat. Maroc, vol. 18, p. 41.—CANU & BASSLER, 1929, U. S. N. M., Bull. 100, vol. 9, pp. 337-339, pl. 39, figs. 8-10.—OKADA, 1929, Sci. Rep. Tôhoku Imp. Univ., Biol., vol. 4, no. 1, p. 29, text-fig. 14.

Diagnosis: The zoarium is flat, unilamellar, thin, somewhat semi-transparent in alcohol, circular with fringe, and incrusting sea-weeds. The zooecia are distinct, separated by salient threads, elongated, elliptical, and arranged in radial lines; the frontal is convex, formed of a rugose pleurocyst surrounded by large areolar pores separated by very prominent costules. The zooecial aperture is elliptical or oval, transverse, with a thin raised peristome with prominent cardelles, forming a large rimule in the middle of the lower lip; the lyrula is salient. The oral spines are usually four, situated on distal border of the peristome. The frontal avicularium is small, round, oval or elliptical, somewhat elevated, placed just below the rimule on the median longitudinal axis of the zooecium. The mandible is acute, pointed down-wards. The ooecium is hyperstomial, placed on the distal zooecium, semicircular, globose, prominently punctured and somewhat porous.

Distribution: Kara Sea (349 m.); Spitzbergen (36–146 m.); Norway (65–486 m.); Denmark; Great Britain; France; Mediterranean Sea; California (18 m.); China Sea (49 m.); Philippines; Indian Ocean; Mauritius: Japan—Mutsu Bay, Aomori-ken; Fukura, Awaji, Wakayama-ken; Sagami-Bay, Kanagawa-ken.

Locality: Several complete colonies were obtained at spots off Manazuru, Hatsushima and Manazuru-zaki.

15. *Smittina landsborovii* (JOHNSTON) 1849.

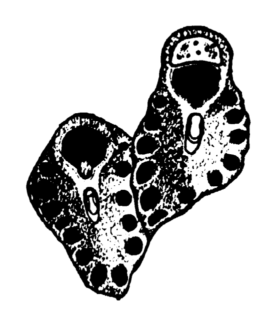
(Plate X, fig. 8; Text-fig. 4.)

Lepralia landsborovii JOHNSTON, 1849, Brit. Zooph., ed. 2, p. 310, pl. 54, fig. 9.—BUSK, 1854, Cat. Mar. Poly. Brit. Mus., 51, p. 66, pl. 86, fig. 1, pl. 102, fig. 1.—HINCKS, Quart. Journ. Micr. Sci., 7, p. 277.

Smittina landsborovii HINCKS, 1880, Hist. Brit. Mar. Poly., vol. I, pp. 341-347, pl. xlviii, figs. 6-9.

Escharella landsborovii, SMITT, 1867, Oefr. k. Vet-Ak. Förh. Bihang, 12 & 92, pl. 24, fig. 63.—SMITT, Floridan Bryoz., pt. 2, p. 60, pl. 10, figs. 201, 202. —OKADA, 1923, Annot. Zool. Jap., vol. 10, art. 22, p. 228.

Diagnosis: The zoarium incrusting shells, unilamellar, milky white in alcohol; the zooecia are arranged alternately in many radial lines from the ancestrula. The zooecia are distinct, elliptical or subhexagonal, somewhat elongated, separated by a furrow; the frontal is a little convex, formed by a thickly granulated pleurocyst bordered by many distinct areolar pores with short costules. The peristome is thin somewhat elevated; the orifice is circular, lunar. or oval, more or less transverse, with a prominent rimule in the middle of the lower margin; the cardelles are indistinct; the lyrula moderate not triforiate. The median frontal avicularium situated just below the rimule, has a semicircular or lip-like, descendent mandible and prominent pivot. The areas round the peristome and avicularium are somewhat elevated and more minutely granulated. The ooecium is hyperstomial, smooth, perforated, deeply imbedded in the distal zooecium, and surrounded thickly by secondary calcification.



Text-fig. 4. *Smittina landsborovii* (JOHNSTONE). Zooecia with an ooecium.

Distribution: Japan—Hamajima, Miye-ken; Chôshi, Chiba-ken; Kurokujima, Yamagata-ken; Shimane-ken.

Localities: Small fragments were obtained at spots off Manazuru, Aziro, and between Hatsushima and Itô.

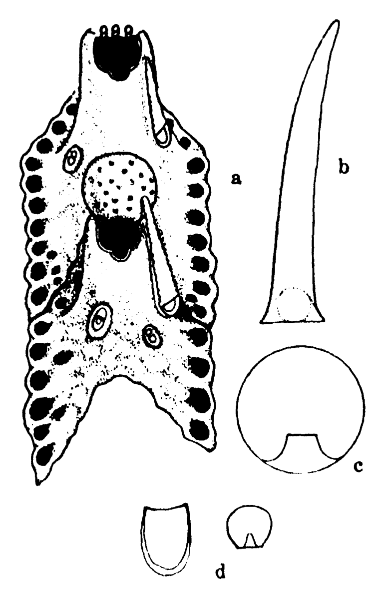
Note: The specimen on our hands are very closely allied to *Smittina marmorea* HINCKS especially in the character of the granulated frontal caused by the secondary calcification, but differs from it in semicircular avicularian mandible.

16. *Smittina projecta* n. sp.

(Plate X, figs. 1-3; Text-fig. 5.)

Diagnosis: The zoarium is unilamellar, thin, incrusting sponges, milky white in alcohol. The zooecia are distinct, rectangular or quadrate, with deeply concaved lower margin, separated by deep furrows and arranged in many radial lines. The frontal is very convex, granular, not perforated, and is surrounded laterally by somewhat small number of deep areolar pores with more or less indistinct

costules. The peristomice is very prominently developed, much elevated, somewhat thick; the orifice is semicircular or elliptical, transverse, with 2 lateral denticles limiting the semicircular median rimules. The aperture is circular with a large lyrula, closed by an operculum but always concealed in the peristomice. The non-ovicelled zooecia have three hollow oral spines distally and the peristome is not entire; the ovicelled zooecia have no spines but entire peristomice. The frontal avicularium is gigantic, situating on one side of elevated peristomice, strongly denticulated marginally, with long, slender, acute triangular mandibles, pointed upwards or downwards. One or two small oval avicularia with semi-elliptical mandibles, situated on the frontal, about the base of peristomice. The ooecia are hyperstomial, imbedded in the distal zooecium, thin, globose, minutely perforated, surrounded by thickly calcified proximal part of the distal zooecium.



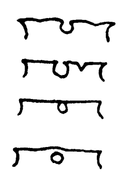
Text-fig. 5. *Smittnia projecta* n. sp.

a. Two zooecia with an ooecium.
b. Mandible of large and narrow avicularium.
c. Innerside of peristome to show the lyrula.
d. Mandibles of smaller avicularia.

17. *Smittina hatsushima* n. sp.

(Plate X, fig. 4; Text-fig. 6.)

Diagnosis: The zoarium forming an unilamellar incrustation, grayish purple in alcohol, consisting of a longitudinal row of zooecia arranged rather regularly. The zooecia are distinct, hexagonal, elliptical, separated by rather distinct furrows; the frontal is granular, somewhat convex, porous, bordered by a line of small circular areolar pores. The peristome is salient, thick, broad, and



Text-fig. 6.
Smittina hatsushima n. sp.
Variations of lyrula.

finely granulated, with a median pseudo-rimule inferiorly; the lyrula is very wide and bifurcated. The ooecia hyperstomial.

Locality: A small complete colony attached to shell was obtained at a spot between Hatsushima and Itô.

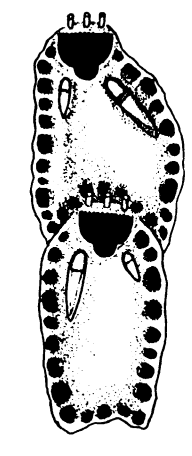
Note: This species is distinguished from other species in the same genus by having the thick, broad, transverse peristome and very wide, bifurcated lyrula.

18. *Smittina rouvillei* CALVET 1902.

(Plate X, figs. 5, 6; Text-fig. 7.)

Smittina rouvillei CALVET, 1902.—CALVET, 1927, Bull. L'Inst. Oceanog. Monaco, no. 503, p. 26, fig. 5.

Diagnosis: The zoarium is incrusting. The zooecia are distinct, rectangular or hexagonal, somewhat elongated or not, separated by a salient thread. The frontal is a litte convex, rugose, shrinkled all over the surface, surrounded by large areolar pores. The aperture is suborbicular or semicircular, transverse, with minutely denticulated distal margin and curved sinuated proximal margin, two lateral denticles and a narrow lyrula occur in the orifice. There are three spines on the upper margin of the peristome. The frontal avicularia are two in number and not equal in size, situated on each side a little below the aperture, with slender, acute, triangular mandibles pointed obliquely downward. The ooecium is hyperstomial.



Text-fig. 7.
Smittina rouvillei CALVET.

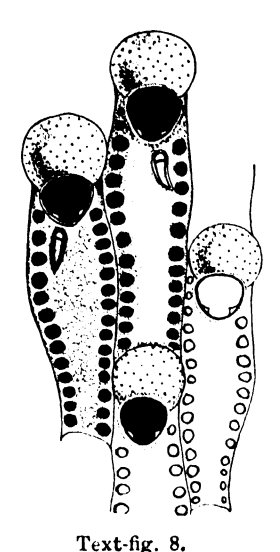
Distribution: Monaco.

Locality: A small fragment was obtained at a spot between Hatsushima and Itô.

Note: This species is close to *Smittina trispinosa* (JOHNSTON) in the presence of three oral spines, but differs from it in the dimorphism of the avicularia.

19. *Smittina elongata* n. sp.

(Plate X, fig. 7; Text-fig. 8.)



Text-fig. 8.
Smittina elongata n. sp.

Diagnosis: The zoarium incrusting sponges; flat, unilamellar, milky white in alcohol. The zooecia are distinct, much elongated elliptical, separated by a furrow, arranged alternately in linear series radiating from the ancestrula; the frontal is flat or slightly convex, finely granulated, surrounded laterally by a line of large areolar pores with short costules. The aperture is suborbicular somewhat attenuated proximally with fig-like appearance; the peristome is thin, slightly elevated, with two lateral cardelles on both sides, but with no lyrula. The frontal avicularium with pivot situated on either side a little below the aperture and has long acute mandibles obliquely pointed downwards. The ooecium is hyperstomial, situated in the distal zooecium, globular, prominent, minutely punctured on the surface.

Locality: A complete colony was obtained at a spot off Fukuura.

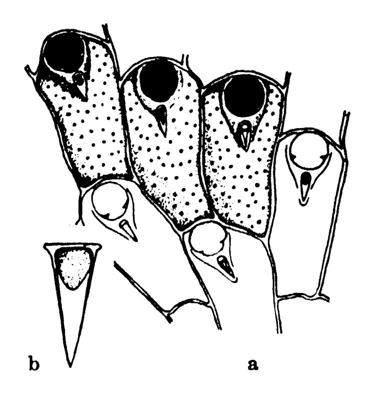
Genus *Codonella* CANU & BASSLER 1927

20. *Codonella acuta* (ORTMANN) 1890.

(Text-fig. 9.)

Lepralia acuta ORTMANN, 1890, Arch. f. Naturg., 56, 1, p. 41, pl. 3, fig. 12.

Diagnosis: The zoarium is unilamellar, incrusting shells, pale brown in alcohol. The zooecia arranged in linear series alternately, are distinct, rectangular, elongate, gradually attenuated proximally, separated by very salient threads. The frontal is little convex, rough, indistinctly granulated and perforated by many minute tremopores. The aperture is suborbicular; the peristome is thin, little salient, with two cardelles limiting a broad median rimule. A single median avicularium is placed just before the aperture, with straight, pointed, triangular, descendent mandibles. The ooecium is hyperstomial, closed by the operculum, circular and granulated.



Text-fig. 9. *Codonella acuta* (ORTMANN).

a. Zooecia. b. Mand ble of frontal avicularium.

Distribution: Japan—Sagami Bay, Kanagawa-ken; Ôshima, Kagoshima-ken.

Locality: Two small fragments were secured at spots off Manazuru and Manazuru-saki.

Note: This species differs from *Codonella obtusata* (ORTMANN), in its pointed median avicularium and rough frontal surface more indistinctly granulated.

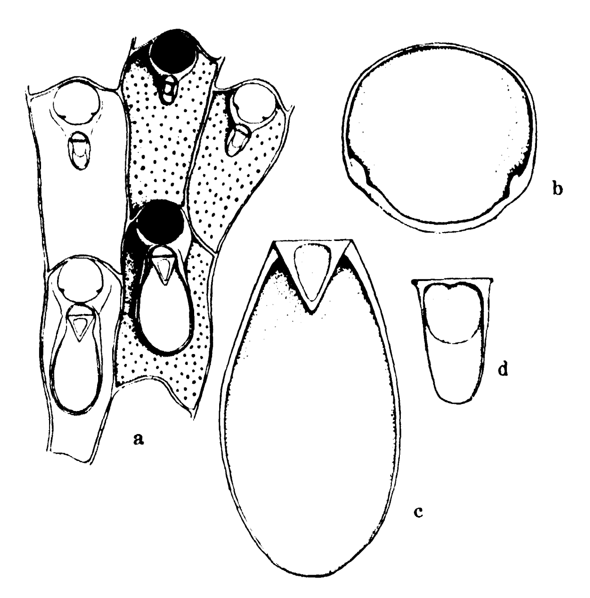
21. *Codonella spatulata* n. sp.

(Text-fig. 10.)

Diagnosis: The zoarium forms a thin incrustation. The zooecia distinct, rectangular, elongated, broad distally, separated by a salient thread. The frontal is a tremocyst, slightly convex, finely perforated by many small pores. The peristome is salient, elevated and complete with two small cardelles limiting a round rimule. The aperture is orbicular, closed by the operculum. The median avicularia are placed below the aperture, more or less elevated from the frontal; dimorphic, the smaller elliptical one with tongue-shaped mandible; the other, with very large spatulate mandibles. The ooecia are unknown.

Distribution: Japan—Senzaki, Yamaguchi-ken.

Locality: A small fragment without ooecium was obtained at a station off Manazuru.



Text-fig. 10. *Codonella spatulata* n. sp.
a. Zooecia with two kinds of avicularia.
b. Operculum.
c. Mandible of large avicularium.
d. Mandible of small aviculaium.

Note: The present species is close to *Codonella acuta* (ORTMANN) in general zooecial features, but peculiar in its gigantic spatulated median avicularia.

Family Tubucellariidae BUSK 1884

Genus Tubucellaria D'ORBIGNY 1852

22. *Tubucellaria cereoides* ELLIS & SOLANDER 1786.

Tubucellaria cereoides ELLIS & SOLANDER, 1786, Nat. Hist. Zooph., p. 26, pl. 5, figs. B-E.—KIRKPATRICK, 1890, Ann. Mag. Nat. Hist., ser. 6, vol. 5, p. 16. —MACGILLIVRAY, 1895, Trans. Roy. Soc. Vict., vol. 4, p. 105, pl. 4, fig. 1.—WATERS, 1907, Journ. Linn. Soc. Lond., vol. 30, p. 129, pl. 15, figs. 8, 9, 15, 16.—WATERS, 1909, Journ. Linn. Soc. Lond., vol. 31, p. 142.—CANU & BASSLER, 1920, U. S. N. M., Bull. 106, p. 542.—ROBERTSON, 1921, Rec. Ind. Mus., vol. 22, p. 53.

Tubucellaria opuntioides CALVET, 1902, Trav. Inst. Zool. Univ. Montpellier, ser. 2, no. 11, p. 28.—CALVET, 1907, Exped. Sci. Trav. Talisman, p. 402.—LEVINSEN, 1909, Cheilost. Bry., p. 305, pl. 16, fig. 4.

Diagnosis: The zoarium is articulated; the segments are cylindrical and long. The zooecia are much elongated, distinct, fusiform; the frontal is convex and covered with small pores; the peristomiale occupies about the upper one-fourth of the zooecia and is not separated from the frontal. The peristome is round, slightly thickened, salient, arranged normally on the segment. The ascopore is situated on the frontal below the peristomiale. The ovicelled zooecia have a much larger external aperture.

Distribution: Nice (45 m.); Saint Florent (40–60 m.); Naples; Adriatic; Aegean Sea; Red Sea; Manaar; Port Elizabeth; Andaman; China Sea; Loyalty Is.; Torres straits; Queensland; New South Wales; Victoria.

Locality: Several fragments which are referable with the present cosmopolitan species were obtained at a spot off Manazuru.

Family Reteporidae SMITT 1867

Genus *Reteporellina* HARMER 1933

23. *Reteporellina denticulata* (BUSK) 1884.

Retepora denticulata BUSK, 1884, Chall. Rep., p. 109, pl. 26, figs. 1 a–d, text-fig. 18.—CALVET, 1906, Rev. Suisse Zool., 14, p. 620.—THORNELY, 1912, Trans. Linn. Soc. Zool., (2), 15, p. 147.—WATERS, 1913, Proc. Zool. Soc. Lond., p. 526, pl. 72, fig. 8.—MARCUS, 1922, Ark. f. Zool. Stockholm, 14, no. 7, p. 15.

Retepora misakiensis OKADA, 1920, Annot. Zool. Jap., 9, pt. 5, p. 616, pl. 8, fig. 1, text-fig. 1 a–e.—BUCHNER, 1924, Zool. Jahrb. Abt. Syst., 48, p. 190, pl. 15, figs. 7, 7a, 8.

Reteporellina denticulata HARMER, 1934, Siboga Exped., pp. 581–585, pl. 35, figs. 21–23. pl. 38, figs. 27–32, text-figs. 25d, 33.

Diagnosis: The zoarium is ramose, more or less cup-shaped, if reticulate usually with very long fenestrae, and in the younger state, without anastomoses and dividing dichotomously. The young zooecia are with low septal ridges, enclosing elongate-hexagonal areas. Frontal pores are two or three, conspicuous. The peristomes are variable with infundibuli-form openings and conspicuous marginal teeth; the marginal peristomes are long, subtubular, and curved outwards; the distal lip is deeply emarginate. The proximal margin of secondary orifice is sinuate and marginal denticles are wanting except sinus-denticles. The frontal avicularia are variable in number,

usually bicuspid. Large infra-fenestral vicarious avicularia are rare, with rostrum widening distally. The primary ooecium is delicate, small, pyriform; the frontal surface with a longitudinal fissure. The basal avicularia are acute, not uncommon at the margins of the branches. The mandibles of frontal avicularia are elongate, ending in 2 or 3 acute teeth.

Distribution: Sandwich Is. (20–40 fms.); Loyalty Is.; Amboina; British E. Africa; Malay Archipelago; Ceylon; Red Sea; Andaman Is.; Japan—Misaki, Sagami Bay, Kanagawa-ken.

Genus *Triphyllozoon* CANU & BASSLER 1917

24. *Triphyllozoon bimunitum* (ORTMANN) 1889.

Retepora bimunita ORTMANN, 1889, Arch. f. Naturg., Jahrg. 56, 1, p. 34, pl. 2, fig. 22.—BUCHNER, 1924, Zool. Jahrb., Syst., 48, p. 205.

Triphyllozoon bimunitum HARMER, 1934, Siboga Expeditie, Mon. 28c, p. 616. pl. 35, fig. 39, pl. 41, figs. 1–8, 11–13, text-fig. 25, 41.

Diagnosis: The zoarium is expanding nearly in one plane; the fenestrae are elongate, rhomboidal; the trabeculae are narrow, usually two or three serial. The labial pore is closed, connecting with the peristome by a labial suture. Large lateral avicularia are conspicuous, inflated, situated at the proximal ends of marginal zooecia; the rostum is narrower at the middle. Other larger avicularia are common on the basal surface; small avicularia are often numerous both frontally and basally in the older parts. The primary ooecium is longer than wide, thickened by secondary calcification; stigma is trifoliate, diverging at nearly 180° or more acute angle.

Distribution: Philippine Is.; New Guinea; Celebes; Kei Is.; Japan—Sagami Bay, Kanagawa-ken.

Localities: Several small colonies were obtained at three spots, off Manazuru-saki, Hatsushima, and between Hatsushima and Itô.



PLATE IX

Explanation of the Plate IX

Fig. 1. *Dakaria bidentata* (ORTMANN) .... (p. 63)

Fig. 2. *Petralia japonica* (BUSK) .... (p. 58)

Fig. 3. *Petraliella umbonata* n. sp. .... (p. 60)

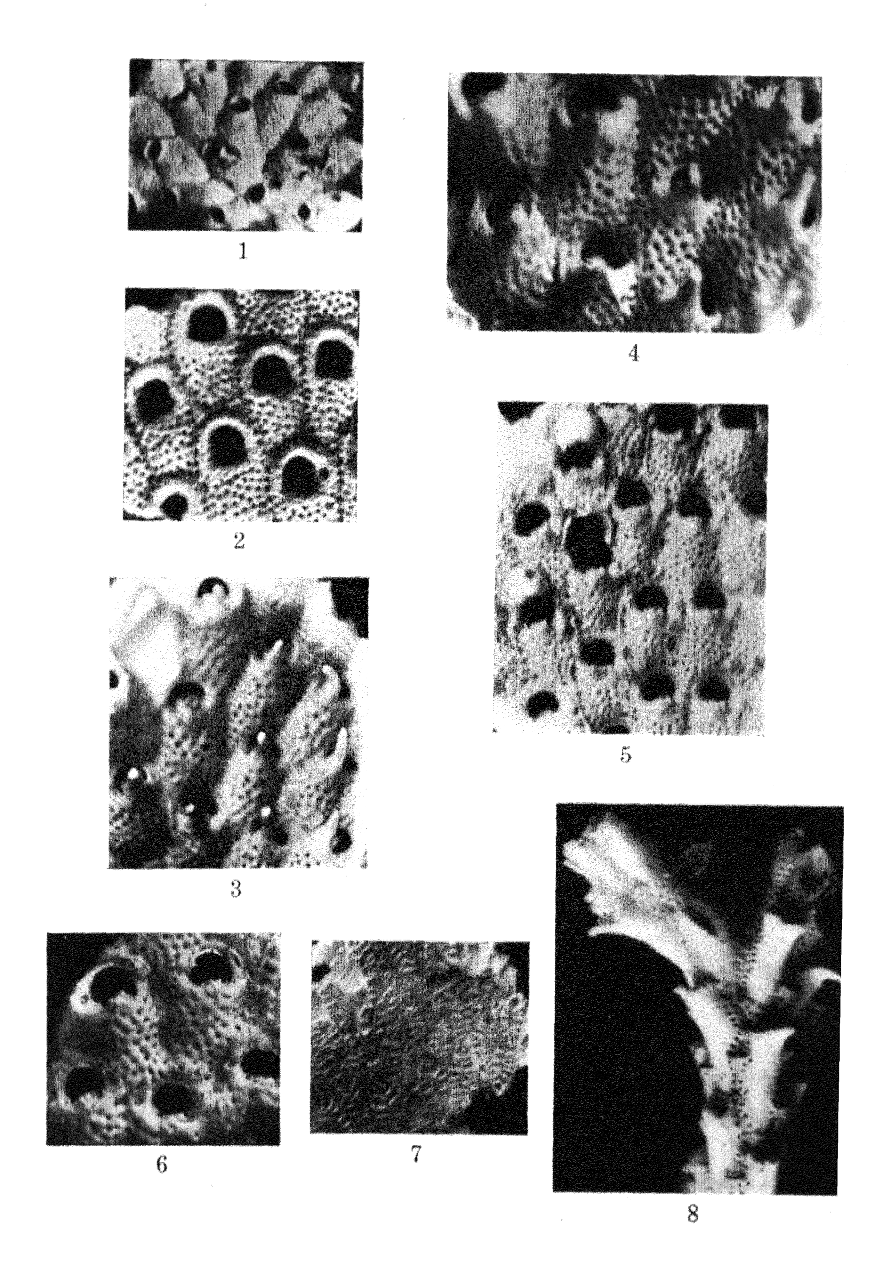
Fig. 4. *Petraliella umbonata* n. sp. .... (p. 60)

Fig. 5. *Petraliella armata* WATERS .... (p. 59)

Fig. 6. *Petraliella armata* WATERS .... (p. 59)

Fig. 7. *Spiralaria spinuligera* HINCKS .... (p. 53)

Fig. 8. *Escharoides ramulosum* n. sp. .... (p. 61)



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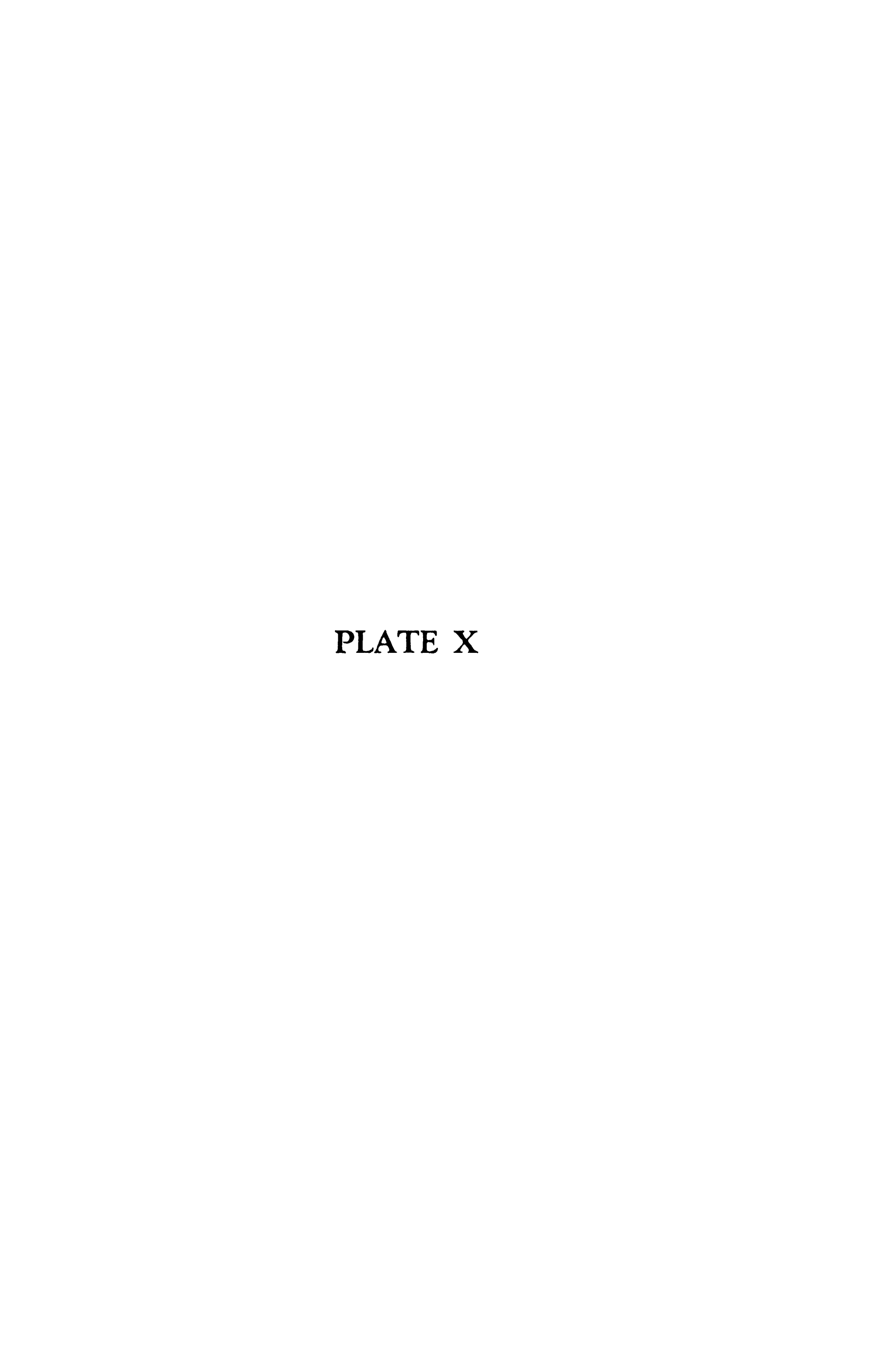


PLATE X

Explanation of the Plate X

Fig. 1. *Smittina projecta* n. sp. .... (p. 66)

Fig. 2. Distal portion of *Smittina projecta* n. sp. .... (p. 66)

Fig. 3. Underside of *Smittina projecta* n. sp. .... (p. 66)

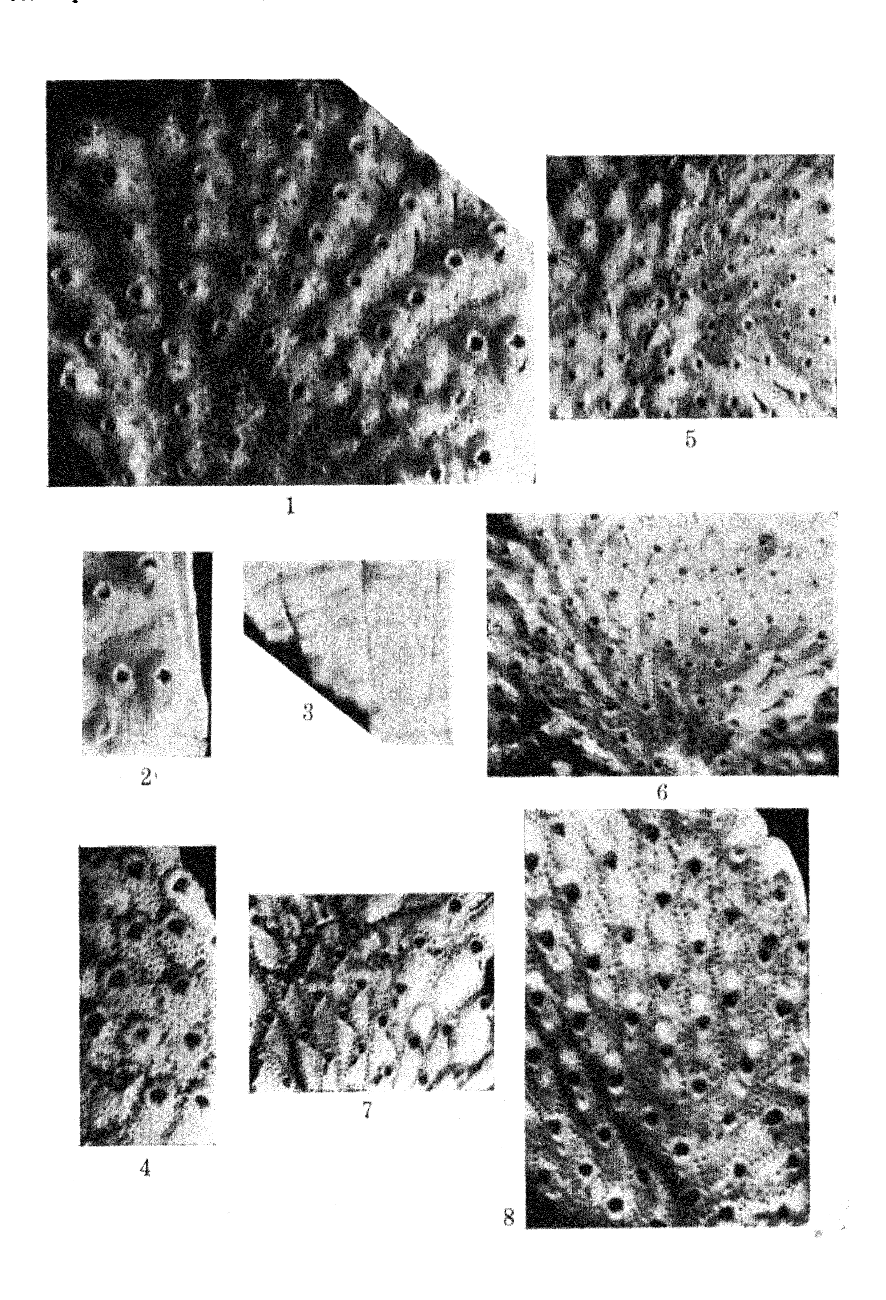
Fig. 4. *Smittina hatsushima* n. sp. .... (p. 67)

Fig. 5. *Smittina rouvillei* CALVET to show the ancestrula .... (p. 68)

Fig. 6. *Smittina rouvillei* CALVET .... (p. 68)

Fig. 7. *Smittina elongata* n. sp. .... (p. 69)

Fig. 8. *Smittina landsborovii* (JOHNSTON) .... (p. 65)



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SCIENCE REPORTS

OF THE

TOKYO BUNRIKA DAIGAKU

SECTION B

SUPPLEMENT No. 1

STUDIES ON THE CRABS OF JAPAN. I. DROMIACEA

By

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TOKYO BUNRIKA DAIGAKU
(Tokyo University of Literature and Science)
KOISHIKAWA, TOKYO

December 16, 1936

NOTICE

The reports are published any time when received, about 300 pages thereof making up each volume.

All communications relating to these reports should be addressed to the chairman of the committee.

Studies on the Crabs of Japan

By

Tune SAKAI

I. DROMIACEA*

[With 9 Plates, 13 Text-figs. and 1 Table]

(Received October 3rd, 1936)

I. Introduction

Since the establishment of the Simoda Marine Biological Station at Simoda, attached to the Tokyo Bunrika Daigaku, the faunal researches of the vicinity of the Izu Peninsula has been an important task to be performed in the first place. Thus, the researches of the marine fauna of Simoda as well as the seasonal Biological Surveys around the Izu Peninsula, toward the Sagami Bay and Suruga Bay, have been repeated through activities of the surveying boats "Misago" and "Amagi". Although the attempt is an undertaking to be continued for a few years hereafter, yet the results of the task seem to be effectual, the specimens of the marine animals deposited in the laboratory of the Station being prodigious in number.

As to the Brachyuran Crustacea, the collections were especially effectual, as the present author himself was a member of those surveying tasks and have entertained special interest to the study of them. Some of the new or rare species in these collections were already reported by the author in 1934 in the second volume of our Science Reports. The author was also much interested in the colours of the fresh specimens and more than 200 figures of crabs in life colours were prepared for report. It was, therefore, the author's earlier intention to publish an illustrated catalogue of the crabs found mainly in the central districts of Japanese Mainland, based on these sketches.

In the meantime, however, the character of the author's work has been somewhat changed. Beside the materials thus collected, a vast number of the specimens of crabs, some common but some exceedingly rare, have been sent to the Simoda Marine Biological Station through the kindness of many local collectors or Institutions in various districts of Japanese territories. It is very probable that

* Contributions from the Simoda Marine Biological Station, Tokyo Bunrika Daigaku, No. 19.

no less than 600 species of crabs now inhabit Japanese waters. A synthetic study of these species is, therefore, before everything necessary, and I deemed it a main purpose of this work to arrange them systematically in a series of papers, giving a brief description and as many figures or photographs as possible to each species. It is to be regretted that the author has not yet succeeded in revising all the Japanese species hitherto reported, so that many gaps among the species are unavoidable at present. I am desirous to fill up these gaps in some future opportunities.

Those sketches in life colours prepared in the surveying seasons, were published by the persuation and encouragement of many elders, from Sanseido, Tokyo, under the tytle of "Crabs of Japan" with descriptions in Japanese, but some of the figures will be reproduced in the present work.

Aside from the collections made by the Simoda Marine Biological Station, the following are the sources of the materials forming the subject matter of this work.

The author wishes to express his sincere thanks to the following gentlemen for their kindness in placing their collections at the author's disposal:—

A vast collection of crabs from the coast of Formosa made by late Mr. SADAE TAKAHASI.

A collection of crabs from the reefs of Daitozima, Loo Choo, made by Mr. HUZIMARO YAMANARI. A part of this collection was sent to Mr. S. YOSHIMURA of the Geographical Institute of the Tokyo Bunrika Daigaku, who in turn sent it to the Simoda Marine Biological Station. Another part was sent to Dr. H. YABE of the Tohoku Imperial University and through the kindness of Mr. T. SUGIYAMA of that University, the author was able to examine these specimens.

Mr. K. OKUDA, the Director of the Kagosima Museum was so kind as to lend us some specimens of crabs preserved there.

Mr. T. TABUKI of the 1st Kagosima Normal School and Mr. K. MIYAI of the Kagosima Zyosi Kôgyô-Gakkô and Mr. T. SAMEZIMA of the Second Kagosima Middle School were kind enough to supply us with their collections of crabs from Kagosima Bay.

Mr. I. KANEKO's vast collection of crabs from Nagasaki were also utilized in this work although most of them were reported by the author in 1933 in the 1st volume of the Science Reports.

A collection of crabs from the coast of Miyazaki-ken made by Mr. S. NAKAZIMA of the Miyazaki Higher Agricultural School.

A collection of crabs from Onomiti Marine Biological Station attached to the Hirosima Bunrika Daigaku, submitted for study by Assistant Prof. I. TAKI and Mr. Y. KINOSITA.

An exhaustive collection of crabs from Tosa Bay, made by Prof. T. KAMOHARA of the Koti High School, and also a small but useful collection by Mr. MITIHIRO of the Koti Zyôtô Middle School.

Vast collections of crabs from the coasts of Kii Peninsula, made respectively by Mr. S. SAKAGUTI of the Wakayama Normal School, Mr. K. OKAMOTO of the Hidaka Middle School and Mr. Y. KUSE of the Yasuda Primary School.

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A collection of crabs from the Ise Bay made by Mr. T. YAMADA of the Wagu Fisheries School.

A collection of crabs from the coast of Aiti-ken made by Dr. Y. MATSUI, Director of the Toyohasi Fisheries Experimental Station.

A collection of crabs from the Masaki Marine Biological Station made by Messrs. M. YERI and N. YOSHII.

A collection of shore crabs from the coast of Iwate-ken made by Mr. G. Toba of the Iwate-ken Normal School.

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Beside these, the author has received many local specimens, submitted for examination by many gentlemen. Some of them are: Dr. S. KOKUBO of the Asamusi Marine Biological Station; Mr. H. SATO of the Tohoku Imperial University; Mr. K. TAKEWAKI of the Tokyo Imperial University; Mr. S. MIYAUCHI in Tokyo; Messrs. I. MIYAZAKI and I. KUBO of the Imperial Fisheries Institute, Tokyo; Mr. K. HOSOYA, Hayama in Kanagawa Prefecture; Mr. T. KAMITA of the Keizyo Normal School, Corea; Mr. S. SERIZAWA of the Keizyo Second Girls' School; Mr. K. BABA of the Amakusa Marine Biological Station; Mr. U. O of the Tyôrôkyô Middle School, Formosa; and many others.

Officially, the author has to express his deep gratitude to the Nippon Gakuzitu-sinko-kai, for the financial help in the course of this study.

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Again it is a grateful task for the author to send his hearty thanks to Dr. M. J. RATHBUN and Dr. W. L. SCHMITT of the U. S. National Museum, to Dr. W. T. CALMAN and Dr. I. GORDON of the British Museum, to Dr. H. BALSS of the "Zoologische Sammlung des Bayer. Staates, München", to Dr. J. E. W. IHLE and Dr. J. J. TESCH of Holland, to Dr. B. PARISI of the Museo di Storia Naturale, Milano, to Dr. F. A. McNEILL and Dr. MELBOURNE WARD of the Australian Museum, to Dr. C. H. EDMONDSON of the Bernice P. Bishop Museum, Honolulu, for their invaluable advise and help in various ways.

In the last place, but not least, the author wishes to acknowledge his thanks to Mrs. SIGEKO SAKAI, for her painstaking labour in preparing all the drawings put on the plates.

II. Synopsis of the Tribe Brachyura*

Class CRUSTACEA

Order DECAPODA

Tribe BRACHYURA

Definition:—Carapace fused with the epistome at the sides and nearly always in the middle; the last of the thoracic sternal somites fused with the rest, its legs usually like the others; the basis and ischium of cheliped and legs immovably united; the abdomen brachyurous (small, straight, symmetrical, bent under the thorax, showing no trace of other function than reproduction, and without

* Definition and keys are those given by BORRADAILE in Ann. Mag. Nat. Hist. ser. 7, vol. 19, 1907.

biramous limbs on the sixth segment). Never a movable antennal scale. Third maxillipeds broad.

Key to the Subtribes of the Tribe Brachyura.

I. Mouth-field (endostome) prolonged forwards to form a gutter. Last pair of legs normal or abnormal. Female openings generally sternal. First abdominal limbs of female wanting. Gills few. ....OXYSTOMATA.

II. Mouth-field roughly square.

A. Last pair of legs abnormal, dorsal. Female openings coxal. First abdominal limbs of female present. Gills usually many. ......DROMIACEA.

B. Last pair of legs normal, rarely reduced, not dorsal, except in Cymopoliidae and Retroplumidae. Female openings sternal. First abdominal limbs of female wanting. Gills few .......................BRACHYGNATHA.

Key to the Superfamilies of the Subtribe BRACHYGNATHA.

a. Fore part of body narrow, usually forming a distinct rostrum. Body more or less triangular. Orbits generally incomplete. ....OXYRHYNCHA.

b. Fore part of body broad. Rostrum usually reduced or wanting. Body oval, round, or square. Orbits nearly always well enclosed. ....BRACHYRHYNCHA.

The present study is expected to be completed in five series, viz.:

I. DROMIACEA (Homolodromiidae, Dromiidae, Dynomenidae, Homolidae).
II. OXYSTOMATA (Dorippidae, Calappidae, Leucosiidae, Raninidae).
III. BRACHYGNATHA, OXYRHYNCHA (Hymenosomidae, Majidae, Parthenopidae).
IV. BRACHYGNATHA, BRACHYRHYNCHA (Corystidae, Portunidae, Atelecyclidae, Cancridae, Xanthidae).
V. BRACHYGNATHA, BRACHYRHYNCHA (Potamonidae, Goneplacidae, Pinnotheridae, Cymopoliidae, Retroplumidae, Ocypodidae, Mictyridae, Grapsidae, Gecarcinidae).

III. Description of Species

(1) Subtribe DROMIACEA DE HAAN.

ALCOCK 1899, p. 124; IHLE 1913, p. 3.

Dromiacea is now generally divided into four families, which are distinguished as follows:

1. No vestiges of sixth abdominal limbs. Carapace longer than broad, with ill-marked side-edge. First three pairs of Pereiopods with mastigobranchs, fourth and fifth small, subdorsal, and prehensile. Sternum of female with sternal sulci.........................Fam. Homolodromiidae.

2. **Vestiges of sixth abdominal limbs present. Carapace usually not much longer than broad, with well-marked side-edge. Sternum of female with sternal sulci.**
   a. **Mastigobranchs on the chelipeds only or none. Third and fourth ambulatory legs small, subdorsal, and usually prehensile ....Fam. Dromiidae.**
   b. **Mastigobranchs on all the first three pairs of pereiopods. Last pair only small and subdorsal ....Fam. Dynomenidae.**
3. **No vestiges of sixth abdominal limbs. Sternum of female without sternal sulci. Eyes incompletely or not at all sheltered by orbits when withdrawn against the body. Linea homolica usually present .... Fam. Homolidae.**

1. Family HOMOLODROMIIDAE ALCOCK.

ALCOCK 1899, p. 127; 1901, p. 31; BORRADAILE 1907, p. 479; BALSS 1927, p. 1013.

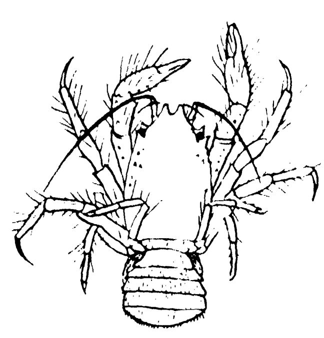
Genus *Dicranodromia* A. M. EDWARDS.

A. M. Edwards 1880, p. 31; A. MILNE EDWARDS & BOUVIER, 1902, p. 14.

Dicranodromia döderleini ORTMANN. Text-fig. 1.

ORTMANN 1892, p. 519, pl. 26, fig. 4; BALSS 1922, p. 104, text fig. 1.

The carapace is sensibly longer than broad, strongly arched down from side to side and the lateral borders sub-parallel. The median frontal tooth is very small and fused with the epistome, so that it is hardly visible from dorsal side. The lateral frontal teeth are strong but obtuse. The supraorbital tooth wanting, but the external orbital angle is very strong and acuminate; the sub-orbital tooth also distinct. The surface of the carapace near the orbital and antero-lateral borders is armed with several sharp spinules but the remainder of the surface is smooth and naked.



Text-fig. 1. *Dicranodromia döderleini* ORTMANN. (After ORTMANN.)

The pereiopods are covered with long stiff hairs. The chelipeds are of

moderate size, arms and wrists have a few spinules on the upper border, the fingers not gaping.

The anterior two pairs of the ambulatory legs are equally strong; the posterior two pairs are very small and chelate, and are dorsal in position. The sternal sulci of the female are strongly convergent anteriorly, terminating in a pair of processes in the interval between the coxae of the third pereiopods.

Abdominal segments are smooth and thickly covered with hairs, convex in the median line.

The above diagnoses were prepared from ORTMANN's original descriptions. I have not yet had occasion to examine this species.

Distribution: Sagami Bay, 150 fathoms (ORTMANN, BALSS).

2. Family DROMIIDAE ALCOCK.

ALCOCK 1899, p. 128; 1901, p. 37; BORRADAILE 1903a, pp. 297–303; IHLE 1913, p. 4; RATHBUN 1923, p. 144.

Key to the Japanese genera of the family Dromiidae.

I. Front cut into three teeth, of which the median one is usually on a lower plane. The sternal sulci of the female reach at least as far as the interval between the coxae of the first ambulatory legs.

1. Third pair of ambulatory legs similar to, though sometimes shorter and thicker than, the fourth pair; both pair being distinctly smaller than the anterior two pairs. Carapace usually convex.

i. Ambulatory legs smooth, lateral frontal teeth not specially dilated to form an eave.

a. Cheliped has an epipodite on its coxa; sternal sulci of the female end apart..*Dromia*.

b. Cheliped has an epipodite on its coxa; sternal sulci of the female end together..*Dromidiopsis*.

c. Cheliped has no epipodite on the coxa; sternal sulci of the female end together..*Dromidia*.

ii Ambulatory legs nodular; lateral frontal teeth more or less dilated to form a lamelliform eave on either side of the front. Sternal sulci of the female end part.

a. Cheliped has no epipodite on the coxa..............*Cryptodromia*.

b. Cheliped has an epibodite on the coxa................*Petalomera*.

2. Third pair of ambulatory legs, though shorter, not less stout than the first two pairs; ending in a huge talon-like dactylus. Carapace flat and pentagonal..*Conchoecetes*

II. Front broadly triangular and notched at tip. Sternal sulci of the female do not quite reach to the interval between the coxae of the second ambulatory legs..*Shaerodromia*.

Genus *Dromia* FABRICIUS.

ALCOCK 1899, p. 136; 1901, p. 43; BORRADAILE 1903a, p. 298; IHLE 1913, p. 21.

Key to the Japanese species of *Dromia*.

1. Carapace broader than long, the four antero-lateral teeth are subequal but the distance between the 3rd and 4th is much greater than those between the 1st and 2nd, the 2nd and 3rd. Dactyli of the first two pairs of ambulatory legs are nearly as long as the propodi. The surface immediately behind the front is smooth and even..............*D. dehaani.*
2. Carapace nearly as long as broad. The four antero-lateral teeth are subequal and equidistant. The first two pairs of ambulatory legs have the dactylus shorter than the propodus. There are two round protuberances arranged side by side immediately behind the front................*D. intermedia.*

1. *Dromia dehaani* RATUBUN. Pl. V, fig. 1.

Dromia rumphii DE HAAN F. J. C. p. 107, pl. 32 (nec. FABR.)

Dromia dehaani RATHBUN 1923, p. 68 (reference and lit.); URITA 1926, p. 1; GORDON 1931, p. 526; SAKAI 1934, p. 282; 1936, p. 31, pl. 1, fig. 1 (coloured).

The carapacae is broader than long, moderately convex and thickly covered with a short pubescence. It is usually scattered by tufts of longer hairs, giving the carapace a more uneven appearance. The front is very narrow, consisting of three subequal teeth, of which the middle one projects from a lower plane. The supraorbital tooth is very small but distinct in every stage of developement. The suborbital tooth is as larger as the frontal teeth. The antero-lateral margins are armed with four similar teeth, the tips of which are smooth and naked. The distance between the first and second teeth is slightly longer than that between the second and third, but is sensibly shorter than that between the third and fourth. These four teeth are thickly fringed with very long hairs, giving the carapace a much broader appearance. The postero-lateral and posterior margins of the carapace are almost straight.

The chelipeds are robust and symmetrical. The upper border of the arm bears six or seven spinules, of which the subdistal one is very large and obtuse. The wrist has two large obtuse nodules, one at the distal end and the other at the outer angle; there are two spinules on the upper inner border of this segment, one at its distal extremity, and the other in the middle. The upper border of the palm

bears four tubercles, of which the one at the distal extremity is always rudimentary and very often so in the proximal one; in a male specimen from Sagami Bay, however, the palm bears only one tubercle in the middle. Thus the number of these tubercles tend to vary individually. These three segments are thickly covered with tufts of long hairs on the inner surfaces. The distal and inner surfaces of the fingers are free from the hairs and are polished. The cutting edge of the immovable finger is armed with about eight teeth, the basal one or two of which are small and the distal one deviates inward so that the tip of this segment appears as if it were bifurcated. The movable finger is armed with about nine teeth, of which the basal two or three are small and the distal one is very small and deviating inward.

The first two pairs of the ambulatory legs are subequal, the anterior and posterior borders of these legs are furnished with very long hairs. The dactyli of these pairs are as long as the propodi (in the juvenile form, the former is somewhat shorter), and are naked along the anterior borders, which are bordered with upper and lower longitudinal row of longish stiff hairs; while their posterior margins have a row of about thirteen to sixteen slender setae. The last two pairs of the ambulatory legs are subequal in length but the third pair is stouter than the fourth pair. The propodi of these pairs are much shortened, both ending in a strong claw-like dactylus which is opposed to a small spinule at the inner end of the propodus.

Material examined:

Tateyama Bay, 1 ♂, May, 1928, author.
Sagami Bay, Manazuru, 2 ♂♂, 1 ♀, 1933, "Misago".
Ise Bay, 1 ♂, Mr. YAMADA.
Kii Peninsula: Seto M. B. L., 1 ♂, Mr. HIRO; Gobo. 1 ♂, 1 ♀, Mr. OKAMOTO; off Wakayama, 1 ♂, Mr. SAKAGUTI.
Tosa Bay, Mimase, 1 ♂, Mr. MITIHIRO; 1 ♂, Prof. KAMOHARA.
Nagasaki, 1 ♂, juv., Mr. KANEKO.

Measurements (in mm):

	(♂ from Sagami Bay.)
Length of carapace	69.5
Width of carapace	82.0
Length of cheliped	123.0
,, 1st amb. leg	118.0
,, 2nd amb. leg	105.0

Length of 3rd amb. leg	....	52.0
,, 4th amb. leg	....	53.0
,, propodus of 1st amb. leg	....	21.0
,, dactylus of 1st amb. leg	....	19.5
,, propodus of 2nd amb. leg	....	21.5
,, dactylus of 2nd amb. leg	....	19.0

Habitat: Muddy bottom, 30 to 100 metres deep, usually buried in a mass of sponge.

Type locality: Kururi, Tokaido, Japan (RATHBUN).

Distribution: Japan (from Hakodate to Kyusyu), Hongkong, Java, Indian Ocean, Gulf of Aden. (RATHBUN.).

2. *Dromia intermedia* LAURIE. Pl. VI, fig. 1.

LAURIE 1906, p. 351; IHLE 1913, p. 23, pl. 1, figs. 1-3.

The carapace is subcircular, nearly as long as broad. The surface of the carapace and the appendages are thickly covered with pubescence, some of which are long and tufted, giving the carapace a more uneven appearance. There are two round protuberances arranged side by side immediately behind the front; the cardiac region is also protuberant, mounted with three indistinct tubercles, the two arranged side by side in front of the other, which is in the median line. Of the three frontal teeth, the median one is very small and on a lower plane, so that it is hardly visible from above. The supraorbital tooth is as large as the lateral frontal teeth, but the suborbital tooth is much larger.

The antero-lateral margins are armed with four similar and equidistant teeth. These teeth are not specially fringed with longish hairs. The chelipeds are as in the former species, but the tubercles upon the wrist are sharper. The upper border of the palm is usually armed with two spiniform tubercles, one at the base and the other in the middle.

The first two pairs of the ambulatory legs are subequal, fringed with hairs on both sides; the dactyli are distinctly shorter than the propodi. The two longitudinal rows of hairs on the anterior border of the dactylus are not so clearly bordered as in the former species. The fourth pair of the ambulatory legs are larger and slenderer than the third pair. The dactylus of the third pair is protected by two

propodal spinules near its base and is opposed to a single spinule at the end of the propodus. The dactylus of the last pair bears a spinule on its posterior slope and is protected by two propodal spinules near its base, opposed to two spinules at the end of the propodus.

Material examined:

Tateyama Bay, 1 ♂, muddy bottom in 30 fathoms, May, 1928.
Sagami Bay, Manazuru, 1 ♀, Feb. 1933, "Misago".
Off Wakayama, 1 ♂, Mr. SAKAGUTI.
Gobo, Kii Peninsula, 1 ♂, Mr OKAMOTO.
Seto M. B. L., 1 ♂, Mr. F. HIRO.

Measurements (in mm):

	(♂ from Seto.)	(♀ from Sagami Bay.)
Length of carapace	37	49
Width of carapace	40	49
Length of cheliped	68	69
,, 1st amb. leg	58	64
,, 2nd amb. leg	56	61
,, 3rd amb. leg	30	33
,, 4th amb. leg	38	45

Habitat: Found on muddy bottom, 30 to 50 fathoms deep.
Type locality: Off Galle, Ceylon (LAURIE).
Distribution: Ceylon, coast of India and Japan (Tokyo Bay, Sagami Bay, Kii Peninsula.).

Genus *Dromidiopsis* BORRADAILE.

BORRADAILE 1903a, p. 298; IHLE 1913, p. 25.

Key to the Japanese species of *Dromidiopsis*.

1. A giant species, carapace measuring more than 100 mm long. Median frontal tooth is as long as the lateral frontal teeth. The fifth antero-lateral tooth is fringed with a brush of long hairs.................. *D. dormia*.
2. A species of medium size, the carapace measuring 50 to 60 mm long. Median frontal tooth is smaller than the lateral teeth. The fifth antero-lateral tooth is not specially fringed with hairs .... *D. cranioides*.

1. *Dromidiopsis dormia* (LINNAEUS). Pl. V, fig. 2.

RATHBUN 1923, p. 67 (syn. and lit.).

The carapace is strongly convex, covered with velvet-like tomentum; the upper surface abruptly rising inside the frontal and lateral

borders. Of the three frontal teeth, the median one is as strong as the lateral, its tip being thick and obtuse. There are no teeth or tubercles on the upper orbital margin, which is deeply separated by a notch from the strong suborbital tooth. The antero-lateral margins are cut into five teeth, of which the first one belongs to the hepatic region and is largest of all, the third one is very small and is on the posterior slope of the second tooth. The last or the branchial tooth is furnished with a brush of long hairs, so that it appears more obtuse than it really is.

The dactyli of the first two pairs of the ambulatory legs are very short and conical. The third ambulatory legs have the distal end normally chelate, but in the chela of the last pair, the dactylus is opposed by two propodal spines, one of which is very small; there is another spinule at the posterior extremity of the propodus near its articulation with the dactylus.

Material examined:

Coast of Gobo, Kii Peninsula, 1 ♂, Mr. OKAMOTO.
Seto M. B. L., 1 ♂, Mr. F. HIRO.

Measurements (in mm):

	(♂ from Seto.)	(♂ from Gobo.)
Length of carapace	110	107
Width of carapace	131	130
Length of cheliped	192	190
,, 1st amb. leg	157	165
,, 2nd amb. leg	142	152
,, 3rd amb. leg	72	73
,, 4th amb. leg	77	91
,, propodus of 1st amb. leg	31	35
,, dactylus of 1st amb. leg	25	23
,, propodus of 2nd amb. leg	32	35
,, dactylus of 2nd amb. leg	21	22

Distribution: After RATHBUN, this species ranges from Hawaii, South Sea, Ternate, Amboina to Red Sea, Mozambique and Cape of Good Hope. Japan (Kii Peninsula) is a new locality for this species in emended sense.

2. *Dromidiopsis cranioides* (DE MAN).

Dromidia cranioides DE MAN 1888, p. 208, pl. 14, figs. 6–8.
Dromidiopsis cranioides, IHLE 1913, p. 26, pl. 1, fig, 4; BALSS 1922, p. 106.

This species was reported from Sagami Bay, at Zusi and Aburatubo by BALSS (loc. cit.), I did not succeed to obtain this species

during the surveying seasons by "Misago" and "Amagi" in Sagami Bay.

Distribution: Amirant, Mergui Archipelago, Andaman Sea, Singapore, Siam, Java Sea, New Guinea and Japan at Sagami Bay (BALSS).

Genus *Dromidia* STIMPSON

BORRADAILE 1903a, p. 299; STIMPSON 1907, p. 170; IHLE 1913, p. 31.

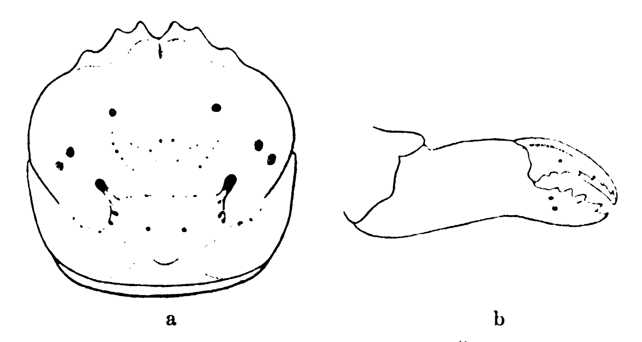
Carapace convex, pilose; hairs often of considerable length. Front narrow, hepatic region more or less concave or excavated anteriorly. Palate is marked by a strong ridge on either side. The posterior feet are longer than the penultimate pair.

No representative of this genus has been reported from Japanese waters till now.

Dromidia unidentata (RÜPPELL). Pl. VI, fig. 2; text-fig. 2.

DE MAN 1888, p. 207, pl. 14, figs. 4, 5; ALCOCK 1901, p. 47, pl. 2, fig. 6; NOBILI 1906, p. 145; LAURIE 1906, p. 351; NOBILI 1907, p. 92; RATHBUN 1910, p. 367; IHLE 1913, p. 31 (literature).

The body is perfectly covered with very long woolly tomentum, so that the outlines of the carapace and appendages are hardly



Text-fig. 2. *Dromidia unidentata* (RÜPPELL).
a. Outline of carapace of female from Seto. (×1.2)
b. Chela of same. (×2.)

perceptible under the natural condition. The carapace is rounded quadrangular, but owing to the strong convexity of the middle part of the carapace, it gives somewhat a globose appearance.

There are several symmetrically disposed dimples on the carapace, the two separating the postgastric from the branchial regions being especially conspicuous, and are perceptible even in undenuded condition. The branchial grooves are deeply marked. The lateral frontal teeth are broadly separated by a V-shaped sinus, below which the usual median tooth is found though in a rudimentary condition. Each of the lateral frontal teeth is broadly united with the obtuse preorbital tooth, the margin connecting them being almost lateral.

The external orbital angle is very obtuse. The antero-lateral margins are entire and thick, rather overhanging. They are furnished with very long woolly hairs, the tips of which project as far as the level of the anterior frontal border. The postero-lateral tooth is of a considerable size but obtuse.

Chelipeds slender, covered with very long tomentum together with the ambulatory legs and the under surface of the carapace. The cutting edge of the immovable finger is provided with five sharp teeth, that of the movable finger with eight smaller teeth. The anterior two pairs of the ambulatory legs are subequal and strong. The fourth pair is not much shorter than either of the two anterior pairs, while the third pair is distinctly smaller. The propodi of the last two pairs are very short, armed with three spines, of which the one on each posterior and anterior extremity is strong, while the other found at the base of the dactylus is rather small. The dactylus is articulated with the propodus at the middle point and is armed with an accessory spinule at its base on the posterior slope. The dactylus of the third pair has no accessory spinule.

Material examined:

Gobo, Kii Peninsula, 1 ♂, Mr. K. OKAMOTO.
Off Wakayama, 1 ♂, Mr. S. SAKAGUTI.
Seto M. B. L., 1 ♂, 1 ♀, Mr. F. HIRO.

Measurements: Male from Gobo, length of carapace 23.5 mm, width 22 mm; female from Seto, length of carapace 31.5 mm, width 31 mm.

Habitat and habit: Found on rocky bottoms, 30 to 50 fathoms deep. The animal was found always carrying upon its back a monascidia.

Distribution: Red Sea, East coast of Africa, persian Gulf, Ceylon, Coromandel coast, Andaman Sea, Malay Archipelago, Mergui

Archipelago, Kermadec Isls., New Guinea, Siam and Japan as reported here. Japan is a new and northernmost locality for this species.

Genus *Sphaerodromia* ALCOCK.

ALCOCK 1899, p. 154; 1901, p. 38; Balss 1922, p. 106.

Sphaerodromia kendalli (AICOCK & ANDERSON).

Dromidia kendalli ALCOCK & ANDERSON 1894, p. 175; Illus. Invest. Crust., pl. 24, figs. 1, 1a.

Sphaerodromia kendalli, ALCOCK 1901, p. 39; IHLE 1913, p. 92 (in list); BALSS 1922, p. 106.

This species was included in the fauna of Japan on the authority of Dr. H. BALSS (1922). I could not study this species myself.

Distribution: Bay of Bengal and Niizima, Izu.

Genus *Cryptobromia* STIMPSON.

ALCOCK 1899, p. 140; 1901, p. 48; BORRADAILE 1903b, p. 299; STIMPSON 1907, p. 172; IHLE 1913, p. 32.

The following is the synopsis of the Japanese species of *Cryptodromia* in chronological order:

STIMPSON (1858) described four species of this genus, namely: *C. tuberculata* from Kikai-sima and Kagosima, *C. tumida* from Amami Ohsima, *C. canaliculata* from Loo Choo and Kikai-sima, and *C. coronata* from Bonin Isls. These species are now known to occur widely in Indian waters. In the following pages I propose to analyse *C. tumida* into three subspecies.

MIERS (1879) reported a doubtful species which was akin to *C. tumida* STIMPSON. It remains doubtful as it was.

HENDERSON (1888) described a new species, *C. japonica* from Yokohama; in 1922 BALSS created a new genus, *Paradromia* to accomodate this species, for it was generically distinct from *Cryptodromia* on account of the presence of an epipodite upon the coxae of the chelipeds. I think, however, *Paradromia* is perhaps better to be considered as a synonym of *Petalomera* STIMPSON. (See p. 68.)

IVES (1892) described a new species, *C. stearnsii* from Japan but with no distinct locality. I think this species is in all probability synonymous with *Petalomera japonica* (HENDERSON).

ORTMANN (1892) described a new subspecies *C. canaliculata ophryoessa*, from Tokyo Bay, but it was referred to a synonym of *Paradromia japonica* (HENDERSON) by BALSS (1922) [viz. *Petalomera japonica*].

IHLE (1913) reported *C. lateralis* (GREY) from Japan but with no distinct locality. This species was referred to *Paradromia* by BALSS (1922), to *Petalomera* by RATHBUN (1923); the latter is acceptable.

PARISI (1915) described a new species, *C. asiatica* from Tokyo Bay, but it was united with *Paradromia japonica* (HENDERSON) by BALSS (1922) [viz. *Petalomera japonica*.].

BALSS (1921) described a new species, *C. ihlei* from Sagami Bay; I think this species is most likely synonymous with *C. areolata* IHLE.

YOKOYA (1933) reported *C. incisa* HENDERSON from Suruga Bay and also a new species, *C. nipponensis* from Wakayama-ken, Tosa Bay and Goto Isls.

In the present opportunity, I am able to add a rare species, *C. bullifera* ALCOCK to the fauna of Japan.

Key to the Japanese species of *Cryptodromia*.

I. Upper surface of carapace non-granular.
  1. True antero-lateral borders cut into three teeth. The lateral frontal tooth and the preorbital tooth are more or less united, forming a lamelliform eave on either side of the front.
    i. Median frontal tooth prominent, projecting beyond the tip of the lateral frontal teeth. There are three to five subhepatic tubercles and two or three supra-sutural teeth .... *C. tuberculata.*
    ii. Median frontal tooth less prominent and much shorter than the lateral frontal teeth. There are only two tubercles on the ventral surface of the carapace, one subhepatic and the other supra-sutural.
      a. Posterior margin of the telson of the male abdomen concave. Sternal sulci of the female terminated in a pair of high processes .... *C. tumida typica.*
      b. Telson of the male abdomen ends in two long spines. Sternal sulci of the female very broad, but with no terminal processes. .... *C. tumida bispinosa.*
      c. The concave posterior margin of the telson of the male abdomen is interrupted by a median tooth .... *C. tumida trispinosa.*

iii. Front almost truncated. Body semispherical, hepatic margin concave. .... *C. nipponensis.*

2. True antero-lateral borders cut into two teeth.

i. A pearl-like tubercle in the middle of the exposed surface of merus of third maxilliped, on the second joint of antenna and also below the suborbital lobe ....*C. bullifera.*

ii. No such tubercles on external surface of third maxilliped etc. Regions of carapace sensibly well defind.

a. Carpus of the cheliped with obtuse nodules. Carapace is canaliculated along the frontal and orbital margins ..*C. canaliculata.*

b. Carpus of the cheliped with sharp tubercles; no such canaliculation on the carapace ....*C. coronata.*

3. Antero-lateral borders with no teeth ....*C. incisa.*

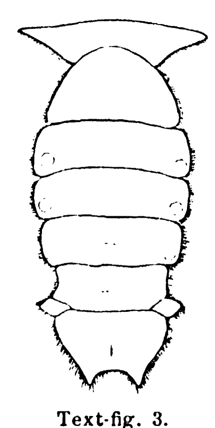
II. Uppper surface of carapace granular.

1. Carapace well areolated, each areola convex. Lateral frontal teeth prominent and curved outward at the tip. With two antero-lateral teeth. ....*C. areolata.*

1. *Cryptodromia tuberculata* STIMPSON. Pl. VI, fig. 3; text-fig. 3.

STIMPSON 1858, p. 239; DE MAN 1887, p. 401; ALCOCK 1899, p. 141; STIMPSON 1907, p. 174, pl. 21, fig. 6; IHLE 1913, p. 35; URITA 1926, p. 1.

The carapace is sensibly broader than in any of the related species of this genus found in Japan; its upper surface is moderately convex and covered with very fine tomentum. The median frontal tooth is slightly longer than the lateral frontal teeth; the preorbital tooth as strong and obtuse as the lateral frontal tooth, these two being almost united with each other to form an eave on either side of the front.



Text-fig. 3.
Cryptodromia tuberculata STIMPSON.
Abdomen of ♂. (×6.)

The true antero-lateral borders are cut into three blunt teeth of subequal size. There is an arched row of three tubercles on the subhepatic region, extending from the lower orbital margin to the ventral side of the first antero-lateral tooth; of these three tubercles, the anterior two are equally prominent and visible from the dorsal side, while the posterior one is inconspicuous or rudimentary.

There is a small, elongate tubercle at the

antero-external corner of the buccal cavern, and on outer side of this, two laterally elongated tubercles are found below the subhepatic tubercles; these three tubercles are arranged on a transverse line.

The chelipeds are symmetrical and strongly tuberculated; the arm is high and its inner surface flat; the wrist bears about 13 tubercles, of which the two or three at the distal and external extremities are very prominent, the four are on the inner margin and of medium size, while the remainder are on the upper surface and are small. The palm has the upper and outer surfaces covered with longish hairs. The fingers are compressed and gaping, the tips alone are naked and glabrous.

The first two pairs of the ambulatory legs are strongly verrucose. The anterior margin of the carpus is armed with three or four tubercles, of which the distal one is most prominent; there is a raised longitudinal ridge on the upper surface of this segment, ending in a prominent tubercle. The posterior margin is non-tuberculated and concave. The propodus has a strong tubercle on the distal end of the anterior border and two compressed ones on the upper surface, one in the middle and the other distal. The posterior border is unarmed.

The abdomen is distinctly seven-segmented. Typically, the third, fourth and fifth segments are respectively armed with four tubercles, two side by side in the middle, and one on either side of each segment. Of these tubercles, the middle two are rudimentary in our male specimen.

Material examined:

Seto M. B. L., 1 ♂, Mr. F. HIRO.

Measurements: Length of carapace 10 mm, width of same 12 mm.

Habitat and habit: Found on rocky shores, carrying a mass of sponge upon its back.

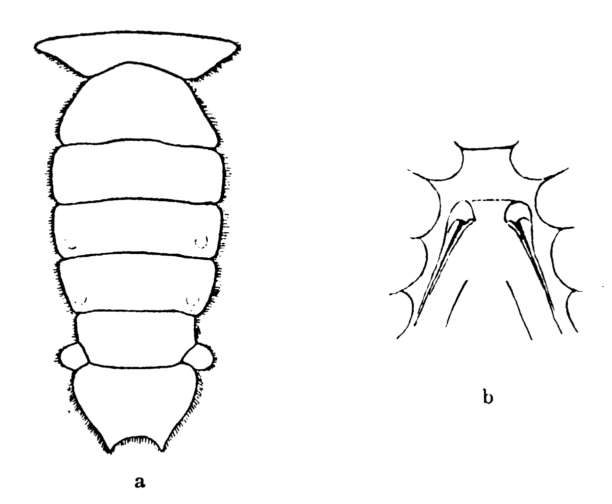
Distribution: Indian Archipelago and Japan: Kagosima, Kikai-sima (STIMPSON); Bonotu in Kagosima prefecture (URITA) and Kii Peninsula (present paper).

2. *Cryptodromia tumida typica* STIMPSON. Pl. VII, fig. 1; text-fig. 4.

STIMPSON 1858, p. 240; ORTMANN 1892, p. 544; DE MAN 1902, p. 688; STIMPSON 1907, p. 175; IHLE 1913, p. 37; PARISI 1915, p. 104; BALSS 1922, p. 107; URITA 1926, p. 1; Montgomery 1931, p. 413, pl. 29, figs. 4, 4a.

This species has frequently been described from various localities in the Oriental region, since its original description was published. The entire animal has, however, never been figured.

After the comparative study of the Japanese materials of this species before me, I was induced to analyse this species into three subspecies which are determined by the character of the terminal segment of the abdomen in the male, and sternal sulci in the female. Aside from these characteristics, there appear to be no other sub-specific diagnoses except for the slight differences in the shape of the antero-lateral teeth and the arrangement of the tubercles on the outer surface of the palm of the cheliped and also of the abdominal segments.



Text-fig. 4. *Cryptodromia tumida typica* STIMPSON.

a. Adbomen of ♂. (×6.)
b. Sternal sulci of ♀. (×4.)

The type specimen of this species is not extant. We are, at present, not quite certain which of the forms hitherto discussed by previous authors really corresponds to the original species, however, those specimens coll. by Mr. SAKAGUTI at the coast of Wakayama-ken are most likely to be admitted as such.

The carapace is smooth and thickly covered with short pubescence, its dorsal surface being abruptly convex behind the front.

The median frontal tooth obtuse, a little shorter than the lateral frontal teeth, which are prominent and united with the preorbital teeth, forming a lamelliform eave on either side of the front. The true antero-lateral borders are armed with three teeth of subequal size. The distance between the first and second teeth is a little shorter than that between the second and third teeth. The tooth behind the branchial groove is very small and far behind the third antero-lateral tooth. There is a strong subhepatic tubercle in the interval between the suborbital tooth and the first antero-lateral tooth. Below this, there is a small tubercle near the anterior end of the lateral sulcus.

The chelipeds are not so strongly nodular as those of *C. tuberculata*; the wrist has three tubercles, each of which is found on the inner, anterior and outer extremities of this segment; there is another inconspicuous tubercle, which is very often absent, on the upper surface near the outer border. The upper border of the palm is armed with four obtuse tubercles, two of which are at its proximal end and the others at the distal end; outer surface of this segment is smooth, a few granules of longitudinal arrangement are found when it is denuded. The fingers in the male are much gaping, while in the female, they are compressed and not gaping.

The first two pairs of the ambulatory legs are subequal. The merus robust, the carpus with a terminal tubercle on the anterior border and the posterior border concave. The propodus is armed with a terminal tubercle on the anterior border. The third pair of the ambulatory legs is sensibly shorter than the fourth pair.

Abdomen of both sexes are smooth and not distinctly tuberculated as described by STIMPSON. As to the terminal segment of the male abdomen, IHLE described it as "Das Telson hat beim geschlechtsreifen ♂ trapezförmige Gestalt. Sein Hinterrand ist fast gerade abgestutzt." In the present specimens, the posteror border of this segment is slightly concave, with an angle on either side of this concave margin. In the case of the female, IHLE described it as "Das Telson ist beim ♀ hinten abgerundet", in our present specimens, it is somewhat trapez-form, the posterior margin being truncated. The sternal sulci of the female are thin and gradually thickened anteriorly, terminated in a pair of prominent processes in the interval between the bases of the first ambulatory legs. (Text-fig. 4, b.)

Material examined:

Off Wakayama, 1 ♀, 3 ♂♂, Mr. S. SAKAGUTI.
Coast of Miyazaki-ken, 1 ♀, Mr. S. NAKAZIMA.

Measurements:

	(♂ from Wakayama.)	(♀ from Wakayama.)	(♀ from Miyazaki.)
Length of carapace	9	9.5	7.0
Width of carapace	10.3	11.9	8.1

Habitat and habit: Found on rocky or stony shore lines, covered with a mass of sponge.

Type locality: Foukow Bay, Ohsima (STIMPSON).

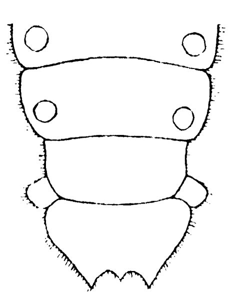
Distribution: Sagami Bay (PARISI, BALSS), Wakayama-ken (present paper), Kagosima Bay, Tanegasima (URITA), Ohsima (STIMPSON), Loo Choo (ORTMANN, BALSS), Malay Archipelago (DE MAN, IHLE); Abrolhos Isls. (Montgomery).

3. *Cryptodromia tumida trispinosa* subsp. nov. Text-fig. 5.

The new subspecies differs from the typical species only in the following few points:

Of the three tuberculiform teeth on the antero-lateral borders, the middle one is not conspicuously more prominent than the others. The fourth to seventh abdominal terga of the male have a very low tubercle on either side.

The telson of the male abdomen resembles that of the typical species, but in the new subspecies, it is distinguished by the presence of a median tooth, by which the posteror margin is divided into two concave portions (text-fig. 5.)
The telson and sternal sulci of the female are unknown.



Text-fig. 5.
Cryptodromia tumida trispinosa subsp. nov.
Abdomen of type ♂.
(×8.)

Material examined:

Coast of Tatugahama, Wakayama-ken, 1 ♂, type, coll. by Mr. Y. KUSE.
Coast of Wakayama, 1 ♂, Mr. SAKAGUTI.

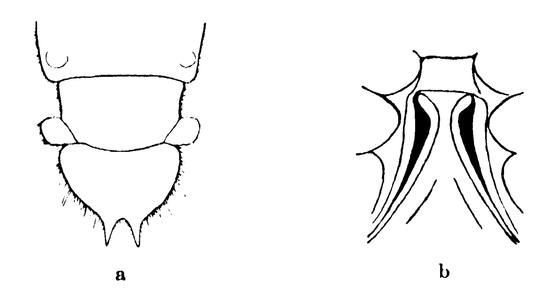
Measurements: Type male, length of carapace 10.4, width 11.5 mm.

Habitat and habit: Found on rocky or stony shore lines, carrying a mass of sponge on its back.

4. *Cryptodromia tumida bispinosa* subsp. nov. Text-fig. 6.

In this new subspecies, the first antero-lateral tooth is nearly as large as the subhepatic tubercle. The second antero-lateral tooth is small and indistinct, the third a little prominent, while the postero-lateral tooth is again indistinct.

The tubercles on the abdominal segments are very low and indistinct. The telson of the male abdomen is armed with a pair of prominent spines on the posterior border; there are sometimes a



Text-fig. 6. *Cryptodromia tumida bispinosa* subsp. nov.

a. Fifth to seventh abdominal segments of type ♂. (×8.)
b. Sternal sulci of ♀. (×4.)

few sharp granules on the outer margins close to these spines. The sternal sulci of the female are very broad but with no terminal processes (text-fig. 6, b.)

This subspecies closely resembles *Petalomera fukuii* described in the future pages, but it can be easily distinguished from the latter by the absence of the epipodite on the coxae of the chelipeds.

Material examied:

Okinosima, Tosa Bay, type ♂, coll. by Prof. KAMOHARA.
Additional materials, 7 ♂♂, 1 ♂, same locality.

Measurements: Type male, length of carapace 9.4 mm, width 11.0 mm; ♂, Paratype, length of carapace 9 mm, width 10 mm.

Habitat and habit: Obtained from coral reefs or crevices of the rocks in a showl water. All the specimens have a mass of sponge upon their backs.

5. *Cryptodromia nipponensis* YOKOYA.

YOKOYA 1933, p. 98, text fig. 39.

This species is distinguished from its congeners by its longer and semispherical carapace, truncated front, concave hepatic margins, etc.

Distribution: Tanabe, Kii peninsula; Muroto-zaki; and Goto Isls. (YOKOYA).

6. *Cryptodromia bullifera* ALCOCK. Pl. VII, fig. 3.

ALCOCK 1899, p. 143; 1901, p. 51, pl. 2, figs. 9, 9a; BORRADAILE 1903, p. 577; LAURIE 1906, p. 352; LENZ 1910. p. 562; IHLE 1913, p. 40.

The carapace as long as broad, somewhat depressed and covered with short hairs. The lateral frontal teeth are very prominent and acute, while the median one is sensibly smaller. The preorbital, postorbital and suborbital teeth are also very prominent.

There are some granules scattered near the frontal and orbital regions when denuded. Of the two antero-lateral teeth, the posterior one is in Japanese specimens not so conspicuously smaller as in the original figure of ALCOCK. The postero-lateral tooth is extremely inconspicuous, but the branchial groove is very deeply marked. In the interval between the anterior antero-lateral tooth and the postorbital tooth, there are two subhepatic tubercles, one below the other.

There is a characteristic pearl-like tubercle on the surface below the suborbital tooth and on the middle of the outer surface of the merus of the external maxilliped; a similar but smaller tubercle is on the exposed surface of the second joint of the antenna.

The chelipeds are robust and symmetrical, the arm bears two prominent nodules, one on the distal end and the other on the outer angle. The palm is armed with two or three spinules on the upper inner border and a prominent nodule at the distal end. The ambulatory legs are not remarkably nodular, the carpi of the first two pairs are grooved on the upper surface.

The abdomen of the male is convex along the middle line; the third to fifth terga have each three tubercles in the median line, one in front of the other two. Each of these segments is also provided with a flat tubercle on either side.

The telson of the male abdomen has the posterior margin rounded.

Material examined:

Gobo, Kii Peninsula, 2 ♂♂, Mr. K. OKAMOTO.
Amakusa M. B. S., 1 ♂, Mr. K. BABA.

Measurements: Male from Kii, length of carapace 12 mm, width 13 mm.

Habitat: Rocky bottoms, 30 to 490 fathoms deep.

Distribution; Japan (Kii Peninsula and Amakusa, Kyusyu); Andaman Sea; Ceylon; Indian Archipelago. The record of its occurrence in Japanese waters is new!

7. *Cryptodromia canaliculata* STIMPSON. Pl. VII, fig. 2.

STIMPSON 1858, p. 240; DE MAN 1887, p. 402; ALCOCK 1899, p. 142; 1901, p. 50, pl. 2, fig. 8; DOFLEIN 1902, p. 652; LENZ 1905, p. 363; NOBILI 1906, p. 145; STIMPSON 1907, p. 176; RATHBUN 1910, p. 367; 1911, p. 194; IHLE 1913, p. 41.

Syn.: *Dromia tomentosa* HELLER 1862.
Cryptodromia tomentosa (HELLER) HILGENDORF 1879.
Cryptodromia hirsuta BORRADAILE 1903.

The carapace is very slightly broader than long, distinctly channeled along the orbital and antero-lateral borders. The regions are fairly well delimited; the upper surface, excepting the said canaliculated areas, is covered with velvet-like tomentum. The three frontal teeth are strong; the median tooth in our material projects a little beyond the lateral ones.

The preorbital tooth obtuse, the postorbital tooth acute and the suborbital tooth also very prominent. Behind the postorbital tooth the hepatic region is concave, the hepatic tubercle, which is on a much lower plane, is hardly visible from above in the undenuded condition.

There are two antero-lateral teeth, the anterior one of which is much larger than the posterior one. The postero-lateral tooth is moderately prominent.

The chelipeds are thickly covered with pubescence, the wrist has a few nodules, which are not pronouncedly pointed. The palm is almost unarmed. The carpi and propodi of the first two pairs of the ambulatory legs are indistinctly nodular, covered with knobbed or feathered hairs. The last two pairs of the ambulatory legs are slender, the third pair being very slightly shorter and stouter than the fourth pair.

The abdomen of the male has the terminal segment rounded on its posterior margin.

Material examined: Coast of Wakayama, 1 ♂, Mr. S. SAKAGUTI.

Measurements: Male, length of carapace 5.5 mm, width of same 6 mm.

Habitat and habit: Inhabits rocky shore, among seaweeds, in the lowest division of the littoral zone (STIMPSON). Carries a mass of sponge or compound ascidians.

Distribution: Kii Peninsula (present paper), Kikaisima, Loo Choo (STIMPSON); this species widely ranges in Indo-Pacific, from the Red Sea and east coast of Africa to Japan.

8. *Cryptodromia coronata* STIMPSON.

STIMPSON 1858, p. 239; DE MAN 1887, p. 398, pl. 18, fig. 2; ORTMANN 1892, p. 543; STIMPSON 1907, p. 173, pl. 20, fig. 2; IHLE 1913, p. 41.

The following description was prepared by STIMPSON:—

"Carapax broader than long, evenly convex; surface minutely roughened with grains and covered with a very short but strongly adhering pubescence. Front very broad, 5-toothed, teeth large and sharply projecting, subequal; middle one somewhat smaller than the others and placed at a lower level; outer or lateral ones situated on the superior margin of the orbit. The inferior orbital tooth is nearly equal in size to those of the front. External hiatus or notch of orbit not deep; tooth at external angle scarcely prominent. Antero-lateral margin 5-toothed, but with two teeth only showing prominently, the posterior tooth being as small as the angle of the orbit, and the second tooth being at a much lower level than the others, and on the subhepatic region. The two large teeth are slightly bilobed, the anterior lobe in each being a sharp tooth, but the posterior one broadly rounded. Feet nodose; tubercles not very numerous, but prominent; interspaces reticulated. This reticulation

is best on the outer surface of the hand, which is entirely covered by it. Chelipeds equal. Fingers very strongly gaping, dentate at tips; dactylus slightly compressed, with a broad, deep sulcus on the front or outer surface, and 2–3–dentate on the inner edge toward base. The feet of the last pair are considerably longer than those of the penult pair. Male abdomen rather broad; last joint much broader than long; penult joint narrower; third and fourth joints each with four spines, the spines short, those of the fourth joint most prominent; a short spine on each side at the posterior angles of the fifth joint. Color lemon-yellow or orange, sometimes blotched with brown on the dorsal aspect. Fingers of chelipeds carmine. Length of carapax in the male, 0.525; breath, 0.56 inch.

The back was covered by a close-grained sponge.

It was found among madrepores at the depth of a fathom, in Port Lloyd, Bonin Island."

Distribution: Bonin Island (type locality, STIMPSON); Amboina (DE MAN); Samoa (ORTMANN); Flores, Sulu, Salawatti, New Guinea, Rotti (IHLE).

It has not yet been reported from the coast of Japanese Mainland.

9. *Cryptodromia incisa* HENDERSON.

HENDERSON 1888, p. 10, pl. 1, fig. 4; ALCOCK, 1901, p. 77; IHLE 1913, p. 31 (in key); YOKOYA 1933, p. 98.

This species is distinguished from its congeners by the absence of the antero-lateral teeth.

It was included in the Japanese fauna on the authority of Dr. Y. YOKOYA.

Distribution: Twofold Bay, Astrakia and Japan, Suruga Bay (YOKOYA).

10. *Cryptodromia areolata* IHLE. Pl. I, fig. 1.

IHLE 1913, p. 47, pl. 2, figs. 10, 11.

Cryptodromia ihlei BALSS 1921, p. 177; 1922, p. 107, text-fig. 2; YOKOYA 1933, p. 98.

The carapace of this small species is somewhat longer than broad. The upper surface well areolated, the areolae being remarkably convex and covered with beaded granules, but with no hairs.

The lateral frontal teeth are very prominent and slightly curved outward at the tip; the median frontal tooth is short and triangular, projecting from a lower plane. The preorbital tooth is distinct but the postorbital tooth is very small, while the suborbital tooth is again prominent.

The antero-lateral borders are divided into two lobes, which are covered with rather sharp granules.

The chelipeds and the anterior two pairs of ambulatory legs are also covered with sharp granules. The wrist of the cheliped bears two obtuse nodules, one at the distal and the other at the outer angle. The palm is crested on the upper inner border, the distal extremity being provided with a nodule. Each segment of the ambulatory legs is not distinctly nodular. The third and fourth pairs of the ambulatory legs are subequal in length but the anterior pair is sensibly thicker. In both cases, the meri are granulated.

The abdominal segments in both sexes are covered with granules but are not conspicuously nodular.

Material examined:

Misaki, Simosita, 1 ♂, 1 ♀, Mr. M. YERI.
Off Manazuru 150 m. deep, 1 ♂, 2 ♀ ♀, Aug. 1936 "Amagi".
Between Ito and Hatusima, 5 ♂ ♂, 4 ♀ ♀, June 1935 "Misago"; 3 ♂ ♂, 2 ♀ ♀, Aug. 1936, "Amagi".

Measurements:

	(♂ from Misaki)	(♂ from Ito)	(♀ from Ito)
Length of carapace	7.0	7.0	6.5
Width of carapace	6.8	6.8	6.0

Habitat and Habit: Found on bottoms of mud or sandy mud or dead shells; depth, 50–300 metres. The specimens collected by "Misago" and "Amagi" had no special protecting animal upon their back.

Type locality: South coast of Timor Island (IHLE).

Distribution: Uraga Canal (BALSS); Sagami Bay (BALSS, present paper); Murotozaki, Bungo Strait, Miyazaki-ken, between Nagasaki and Kosiki Isls. (YOKOYA); Timor Island (IHLE).

Remarks: The specimens which I examined were obtained from the same locality with the type of *C. ihlei* BALSS 1921, which, however seemed to be identical with *C. areolata* IHLE 1913. One female specimen was sent to Dr. BALSS for comparison with the type of *C. ihlei*, and I was able to ascertain my speculation by the kind in-

formation of Dr. BALSS that both species are really identical. *C. areolata* was described from a single fragmental specimen from south coast of Timor Island and the granulation of the upper surface of the carapace seems to be somewhat coarser than in BALSS' figure; yet, if further specimens from various localities were examined, this discrimination should probably disappear. In IHLE's specimen, the carapace is characterized by having the length and width nearly equal; in BALSS' figure, it is longer than broad. (Confer above described measurements.)

Genus *Petalomera* STIMPSON.

STIMPSON 1858, p. 226; ALCOCK 1899, p. 147; 1901, p. 55; BORRADAILE 1903b, p. 300; IHLE 19 3, p. 48.
Paradromia BALSS 1921, p. 178; 1922, p. 108.

The definition of *Petalomera* given by STIMPSON must be now amplified in some respects, on account of the increased number of the congeners.

The carapace is usually longer than broad, but in a few species, it is sensibly broader than long. The upper surface is thickly or sparsely granulated or non-granulated and thickly covered with tomentum. The lateral frontal teeth are always prominent, having a tendency to unite with the preorbital teeth, forming more or less a lamelliform eave on either side of the front.

The epimeron of the typical species is not perfectly indurated and membranous, but in some species, it is perfectly indurated. Typically, the meri of the anterior two or three pairs of the pereiopods have the upper borders dilated to form a lamelliform expansion, but in some species, recently referred to this genus, the meri are normal as in other related genera.

The most remarkable character of this genus, distinguished from the nearest kin, *Cryptodromia,* is the presence of a small epipodite on the coxae of the chelipeds.

The sternal sulci of the female are widely separated from each other, terminating on the level between the coxae of the first ambulatory legs.

I am convinced that *Paradromia* BALSS (1922) is in all probability synonymous with the present genus.

In Japanese waters, eight species are now known of this genus, four being referable to new species.

Key to the Japanese species of *Petalomera*.

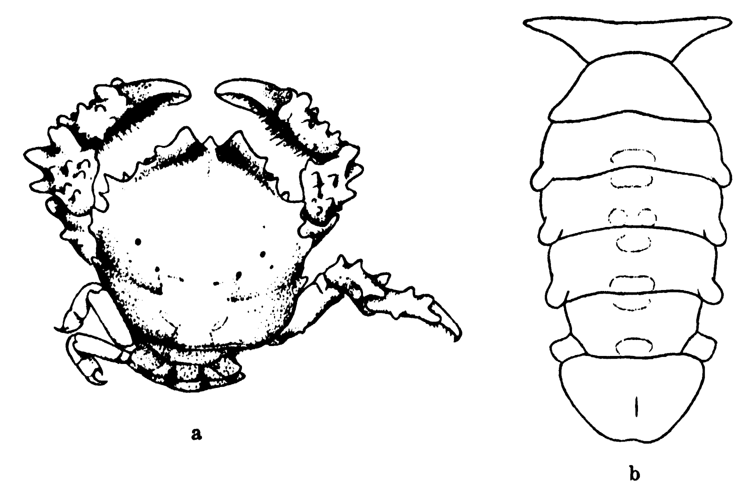
I. Carapace smooth, or very sparsely granular.
  1. Carapace non-granular. The hepatic regions with no tubercles.
    i. The surface of carapace smooth and convex, more or less rising abruptly behind the front.
      a. True antero-lateral borders are cut into four teeth. Chelipeds and abdominal terga (3rd to 5th) are provided with high tubercles .... *P. angulata.*
      b. True antero-lateral borders are cut into three beeth. Chelipeds and abdominal terga are armed with low tubercles .... *P. fukuii.*
      c. True antero-lateral borders are cut into two teeth. Chelipeds and ambulatory legs are armed with obtuse nodules............ .... *P. lateralis.*
      d. True antero-lateral borders are entire, showing several spiniform tubercles on denudation.............................. *P. atypica.*
    ii. The regions of carapace are clearly defined by soft tomentum of unequal length. The antero-lateral borders are cut into two obtuse teeth .... *P. wilsoni.*
  2. Carapace sparsely granular. The hepatic regions with a large tubercle in the interval between the orbit and the anterior antero-lateral tooth. .... *P. japonica.*

II. Carapace (and appendages also) profusely granular. The regions of carapace well defined and areolated.
  1. Anterior three pairs of pereiopods have the meri petaloid in shape. The carapace with no remarkable nodules .... *P. granulata.*
  2. Meri of the anterior three pairs of pereiopods not petaloid. Carapace and abdomen with paired high nodules .... *P. nodosa.*

1. *Petalomera angulata* sp. nov. Text-fig. 7.

The carapace nearly as long as broad, smooth and gradually rising behind the front. The lateral frontal teeth are very prominent, so that the carapace appears rather more oblong than it really is. The median frontal tooth is very small. The pre- and post-orbital teeth are distinct and the suborbital tooth very strong. The true antro-lateral borders are cut into four teeth, of which the first and third are strong, the second and fourth are very small and on the posterior slope of the former. (On the right side, the fourth tooth is rudimentary.) Behind the suborbital tooth, there is a strong subhepatic tubercle and below this, a small tubercle near the anterior end of the lateral sulcus. The antero-external angle of the buccal cavity is armed with two compressed tubercles.

The chelipeds are remarkably tuberculated; the arm with three small tubercles on the upper surface near the distal end, its inner surface being somewhat flat but not especially petaloid in shape.



Text-fig. 7. *Petalomera angulata* sp. nov.

a. Dorsal aspect of holotype. (×2.5.)
b. Abdomen of same. (×5.)

The wrist bears about eleven high tubercles on the upper and outer surfaces, of these the two at the distal margin and the one at the base of the outer margin are very strong and conical. The palm bears about eighteen tubercles, of which the one at the distal end is the most prominent. The fingers gaping, the prehensile edges are armed with seven or eight sharp teeth.

The anterior two pairs of the ambulatory legs have the meri not especially petaloid in shape, the ischia and meri bear a small tubercle on the posterior border. The carpi bear three high tubercles on the anterior border and also one on the upper, distal extremitiy and two very small ones on the posterior border. The propodi bear two on the anterior border, two on the upper surface. The dactyli are strongly curved at the tip, armed with four spines on the posterior border.

The fourth ambulatory legs are slightly longer but sensibly slenderer than the third pair.

The third to fourth terga of the male abdomen bear a high tubercle on each side; the fourth tergum has also two median tubercles arranged laterally on the posterior margin.

The telson has the posterior margin sub-truncated.

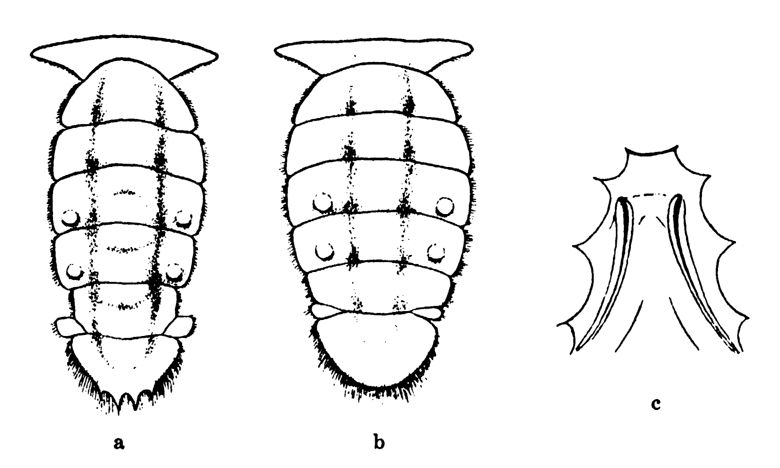
Material examined: Simoda, holotype, obtained from a rocky shore, June, 1932.

Measurements: Length of carapace in median line 11.5 mm, width measured between the 3rd antero-lateral teeth, 12 mm.

Habitat and habit: Found on rocky shore at low water mark; the animal was covered by a mass of sponge.

2. *Petalomera fukuii** sp. nov. Pl. I, fig. 2; text-fig. 8.

This species so much resembles *Cryptodromia tumida bispinosa* mihi that the two species may be confused with each other at first sight. The new species, however, has a small epipodite on the coxae of the chelipeds, while the other has none; thus they are generically distinct.



Text-fig. 8. *Petalomera fukuii* sp. nov.

a. Abdomen of ♂. b. Abdomen of ♀. c. Sternal sulci of ♀.
(a, ×4.5; b, ×3; c, ×3.5.)

* I have a pleasure in dedicating this species to Prof. T. FUKUI, the Director of the Simoda Marine Biological Station.

The carapace is broader than long, abruptly rising behind the frontal and orbital regions. The preorbital and lateral frontal teeth are prominent, both are united with each other, forming a lamelliform eave on either side of the front. The median frontal tooth is small and on a lower plane. The postorbital and suborbital teeth are distinct, the latter being very prominent. The true antero-lateral borders are armed with three teeth, of which the first is most prominent and the second very small. The postero-lateral tooth is also distinct, with a deep indentation in front of it. The sub-hepatic tubercle is as strong as the first antero-lateral tooth, and below this, there is a small tubercle near the anterior end of the lateral sulcus.

The chelipeds almost resemble those of *Cryptodromia tumida bispinosa*, the wrist is armed with two large nodules on the distal and outer angles and also several small granules on the upper surface. The palm is provided with two or three large nodules and a few small granules on the upper surface, with numerous small tubercles arranged in longitudinal rows on the outer surface. The fingers of the male are much gaping, touching only at the tips; the movable finger has an obtuse tooth in the middle. In the female, the fingers are compressed and not gaping.

The anterior two pairs of the ambulatory legs are very strong. The carpus has three or four small granules and a large terminal nodule on the anterior border, and a small tubercle on the upper surface near the end; the posterior border unarmed and concave. The propodus has an obtuse nodule on the distal extremity of the anterior border. The dactylus strongly curved inward, its posterior border has four sharp spinules. The fourth ambulatory legs are sensibly longer than the third pair.

The fourth and fifth abdominal terga have a low tubercle on either side. The telson of the male is rounded triangular, its posterior border being armed with four sharp spinules. The sternal sulci of the female are very slender, not specially terminating in a pair of processes.

Material examined:

Type male, obtained from a showl water in front of the Simoda M. B. S., June, 1932.

23 ♀♀, 21 ♂♂, from various stations in the vicinity of Simoda.

1 ♂, Okinosima, Tateyama Bay, May, 1928.

Measurements: Type male, length of carapase in median line, 13 mm, width 15 mm.

Habitat and habit: Found on rocky or stony shore at lower tidal zone. The animal is protected by a lump of sponge (usually *Reniella*) or compound ascidians (*Botrylloides*).

Distribution: Tokyo Bay, Izu Peninsula.

3. *Petalomera lateralis* (GRAY).

Dromia lateralis GRAY, Zool. Misc., 1831, p. 40 (not seen).
Crtyptodromia lateralis, MIERS 1884, p. 259; STIMPSON 1907, p. 174, pl. 20, fig. 3; ALCOCK 1901, p. 77.
Petalomera lateralis, RATHBUN 1923, p. 153 (and synonymy).

This species was included in the fauna of Japan on the authority of J. MIERS (1884) from Madjica-Sima*?
I have not yet succeeded to obtain this species. In the Simoda M. B. S., there are 1 ♂ and 2 ♀♀ of this species from N.S.W. kindly sent by Dr. MELBOURNE WARD in exchange.

Distribution: Australia and Japan (?).

4. *Petalomera atypica* sp. nov. Pl. II, fig. 1.

The carapace subpentagonal, slightly longer than broad. Its upper surface is convex and thickly covered with tomentum. The regions are almost indistinct.

The lateral frontal teeth are very long and widely separated by the median U-shaped sinus, on the ventral side of which the median frontal spine is also very prominent. The preorbital spine is very long and sharp as well as the suborbital tooth, while the postorbital tooth is not very prominent.

The antero-lateral borders are entire, bearing several sharp tubercles, of which the foremost one behind the postorbital tooth is sensibly prominent, the carapace being broadest at this point. The branchial groove is very shallow, the postero-lateral borders also bear several fine tubercles.

The pereiopods have the meri not petaloid contrary to the typical character of this genus, but the chelipeds have a usual small epipodite on the coxa, so that I referred this species to *Petalomera*. The chelipeds are robust, the inner surface of the ischium and arm

* We cannot identify such a locality in Japanese territories.

are smooth and naked, the upper and lower borders of these segments are tuberculated. The wrist bears two prominent nodules and its upper, outer surface tuberculated. The palm is coarsely tuberculated on outer and inner surfaces as well, but the tubercles are entirely concealed by the tomentum.

The anterior two pairs of ambulatory legs are subequal and very slender, having neither nodules nor spines on any segment. The propodi and dactyli are especially slender, the former are a little longer than the latter, which are curved inward and bear several sharp setae on the inner border. The posterior two pairs of legs are very small and chelate as usual.

Material examined: Male holotype, Between Ito and Hatusima, 50 m. deep, Aug. 1936, "Amagi".
Allotype, Mituisi, off Manazuru, 100 m. deep, Aug. 1936, "Amagi".

Measurements: Holotype, length of carapace measured from the tip of the median frontal spine, 7 mm, width 6 mm.

Habitat and habit: Found on shelly or sandy ground, 50 to 100 metres deep. It was protected by a mass of compound ascidians.

5. *Petalomera wilsoni* (FULTON and GRANT). Pl. I, fig. 4; text-fig. 9.

Cryptodromia wilsoni FULTON and GRANT 1902, p. 61, pl. 9 (not seen).
Dromia pseudogibbosa PARISI 1915, p. 102, pl. 2, figs. 1, 2; BALSS 1922, p. 106; YOKOYA 1933, p. 97.
Petalomera wilsoni, RATHBUN 1923, p. 154, pl. 42, fig. 1; SAKAI 1936, p. 33, pl. 1, fig. 3 (coloured).

The carapace is distinctly broader than long, the upper surface being convex and thickly covered with soft tomentum. The regions are elegantly defined by the different length of the tomentum, but in a denuded condition, they become less conspicuous excepting the branchial grooves and an indistinct groove between the gastric and cardiac regions.

The lateral frontal teeth are united with the more prominent preorbital teeth, forming a remarkable lamelliform eave on either side of the front. The median frontal tooth is very small and on a lower plane. There is a pair of low protuberances, arranged side by side immediately behind the front. The postorbital tooth is rudimentary.

The true antero-lateral borders are cut into two prominent teeth of equal size; the postero-lateral teeth are equally strong but project

rather outward. The sub-hepatic tubercles are slightly smaller than the antero-lateral teeth.

The meri of the anterior three pairs of the pereiopods have the inner surface flat and smooth, but the upper borders are not so distinctly dilated to form a lamelliform expansion as in the typical species of this genus.



Text-fig. 9. *Petalomera wilsoni* (FULTON & GRANT).
Outline of carapace of two specimens.
(a, ×3.2; b, ×1.)

The wrist of the cheliped bears two nodules, one at the distal end and the other at the outer angle; the inner angle of this segment is armed with a sharp tooth, which is covered with long silky hairs. The palm is less conspicuously nodular; in the case of the male, the upper border is studded with several granules beneath the tomentum, but in the female, the granules are almost rudimentary. The inner surfaces of these segments are thickly covered with long, silky hairs. Both inner and outer surfaces of the fingers are longitudinally grooved and covered with tomentum, the distal surface alone is naked and glabrous. The meri and carpi of the anterior two pairs of the ambulatory legs bear a tuberculiform nodule at the distal end of the anterior border.

The telson of the male abdomen is trigonal, while that of the female has the posterior border sub-truncated.

Material examined:

Manazuru in Sagami Bay, 5 ♀♀, 3 ♂♂, Oct. 1932.
Off Hukuura in Sagami Bay, 3 ♀♀, 5 ♂♂ (all juv.), June, 1935, "Misago".
Simoda, 15 ♀♀, 12 ♂♂, Simoda M. B. S.
Wagu, Ise Bay, 2 ♀♀, 3 ♂♂, Mr. YAMADA.
Mimase, Tosa Bay, 1 ♂, Mr. MITIHIRO.

Measurements: Male from Simoda, length of carapace in median line 23 mm, width 32.5 mm; juvenile female from Fukuura, length of carapace 4.3 mm, width 4.6 mm. It is obvious that in the juvenile form, the carapace is conspicuously longer in proportion to width when compared with the adult specimens (text-fig. 9).

Habitat: Sublittoral, rocky or pebbly ground; depth, 20 to 100 metres.

Type locality: Port Phillip Heads.

Distribution; Japan from Aomori Bay to Kyusyu (YOKOYA) and above locality.

5. *Petalomera japonica* (HENDERSON), new combination. Pl. VIII, fig. 1.

Cryptodromia japonica HENDERSON 1888, p. 6, pl. 1, fig. 2.
**Cryptodromia Stearnsii* IVES 1892, p. 216, pl. 12, figs. 1–3; ALCOCK 1901, p. 77; IHLE 1913, pp. 33, 90 (no new record),
Cryptodromia canaliculata ophryoessa ORTMANN 1892, p. 545.
Cryptodromia asiatica PARISI 1915, p, 105, pl. 2, fig. 3.
Paradromia japonica, BALSS 1922, p. 108, text-figs. 3–4; SAKAI 1934, p. 282; 1936, p. 32, text-figs. 1–2.

The carapace is nearly as long as broad, moderately convex and sparsely granulated beneath the tomentum, but the posterior surface is perfectly non-granular. There are impressed grooves in the form of an H in the middle of the carapace, so that the gastric, cardiac and branchial regions are well separated. The lateral frontal teeth are very prominent and blunt, continued to the preorbital teeth, their lamelliform margins are somewhat reflected upward. The median frontal tooth is very small and blunt, projecting from a lower plane. There are two low protuberances arranged side by side behind the front. The hepatic regions have a tubercle in the interval between the orbit and the first antero-lateral tooth. The true antero-lateral borders are cut into two subequal teeth, and behind these a prominent postero-lateral tooth follows, separated by the deep branchial groove.

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* After IVES, *Cryptodromia stearnsii* is distinguished from *Petalomera japonica* in having three teeth on the antero-lateral border instead of two. This discrimination, however is not essentially important, because *Petalomera japonica* has also three teeth on the antero-lateral border, one on the hepatic region and the other on the true antero-lateral margin. As to the presence or absence of the epipodite on the cheliped of *C. stearnsii*, we are quite ignorant, but after comparing the original description and figure of IVES with the present species, I am convinced that both species may probably be identical.

On the anterior ventral surface of the carapace, there are three tubercles, of which the one on the posterior slope of the suborbital lobe is the most prominent and compressed, the other two are on the subhepatic region and are found on a line connecting the antero-lateral teeth with the antero-external angle of the buccal cavern, which is also armed with a low tubercle.

The epimerons are almost perfectly indurated.

The anterior three pairs of the pereiopods have the meri not specially petaloid in shape. The wrist of the cheliped has two large nodules, one at the distal end and the other at the outer angle; its upper surface is sparsely granulated. The palm has two terminal nodules on the upper surface, which is also sparsely granulated. The fingers are not much gaping. The meri and carpi of the first two pairs of the ambulatory legs are armed with a nodule at the extremity of the anterior border. The fourth ambulatory legs are longer and slenderer than the third pair.

The third to sixth abdominal terga have a low tubercle on either side. The telson of the male abdomen is subtruncated on the posterior margin.

Material examined:

Tateyama Bay, 3 ♂♂, May, 1928.
Hirado, Nagasaki, 1 ♀, Mr. I. KANEKO.
Kesen-gun, Iwate-ken, 1 ♂, Mr. G. Toba.

Measurements: Male from Tateyama Bay, length of carapace 19.5 mm, width 20.3 mm.

Habitat and habit: Found on muddy or sandy bottoms, 10 to 100 meters deep. The animal was protected by a lump of sponge.

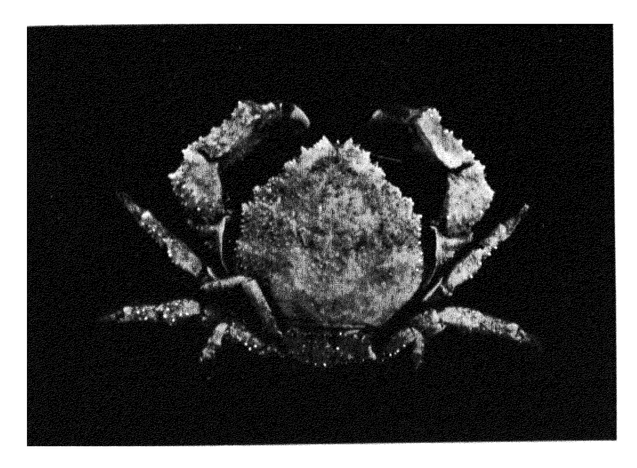
Type locality: Yokohama (Challenger).

Distribution: Tokyo Bay, Nagasaki, and Foukou Bay (IHLE).

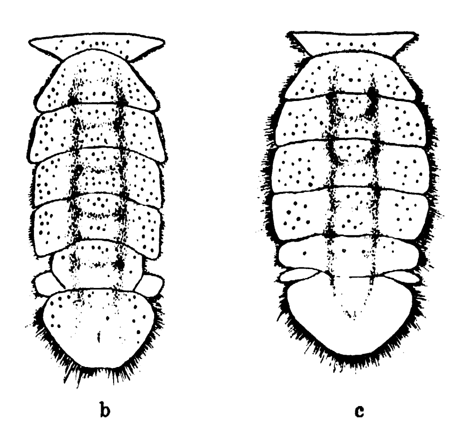
6. *Petalomera granulata* STIMPSON. Pl. I, fig. 3; text-fig. 10.

STIMPSON (1858) 1907, p. 179, pl. 21, fig. 4; ALCOCK 1901, p. 78; IHLE 1913, p. 91 (in list); SAKAI 1936, p. 33, pl. 1, fig. 2 (coloured).
Petalomera granulata indica, URITR (nec. ALCOCK ?) 1926, p. 1.
(Not *Petalomera granulata*, SHEN 1932; it seems to be related to *P. japonica*.)

The carapace is elongate-pentagonal and hardly at all hairy; the regions are well defined and covered everywhere with fine vesiculous granules, but in the juvenile specimens the intestinal and



a



b c

Text-fig. 10. *Petalomera granulata* STIMPSON.

a. ♂ from Tokyo Bay. b. Abdomen of ♂. c. Abdomen of ♀.
(a, nat, size; b, c, ×2.)

posterior surfaces are smooth. The lateral frontal teeth are sharply acuminated and serrated, the median frontal tooth is very small and on a lower plane. The preorbital and suborbital teeth are also prominent but the postorbital tooth is indistinct; all these teeth are finely serrated as well. The true antero-lateral borders are cut into three sharply granulated teeth, the anterior one of which belongs to

the hepatic region and is on a lower plane. There is no distinct tooth behind the branchial groove.

The chelipeds are very stout and sharply granulated. The inner surface of the arm is very smooth and flat, its upper margin is exceedingly delated to form a lamelliform expansion. The wrist bears two acuminate prominences at the distal end; the palm has a terminal prominence, the upper surface of these segments are covered with vesiculous granules already mentioned. The first two pairs of the ambulatory legs are subequal and granular; the merus of the first pair is not remarkably so. The posterior two pairs of the ambulatory legs are very small and subequal, but the last pair is sensibly slenderer and alone is dorsal in position. Abdomens of both sexes are as figured in the text-fig. 10, b. c.

Variation: In a considerably larger specimen (C. L. 31 × C. W. 30), the whole carapace is granulated except the grooves separating the regions and also the upper orbital surfaces. In the smaller specimens, the surface near the posterior border is smooth together with those above mentioned surfaces. The second ambulatory legs have the merus always less distinctly petaloid in shape. *P. granulata indica*, reported by URITA from Kagosima Bay (1926) is in all probability the same with the typical species; I was able to revise his specimen by the permission of the Kagosima Museum.

Material examined:

Tateyama Bay, 2 ♂♂, May 1928.
Between Ito and Hatusima, 1 ♂, June 1935, "Misago"
Kagosima Mus , 1 ♂.
Amakusa, 1 ♂, The Tomioka Primary School.

Measurements: Male from Tateyama Bay, length of carapace in median line 30 mm, width also 30 mm.

Habitat and habit: Found on muddy, shelly or sandy grounds, 50 to 150 metres deep. Protected by a mass of sponge.

Type locality: Kagosima Bay (STIMPSON).

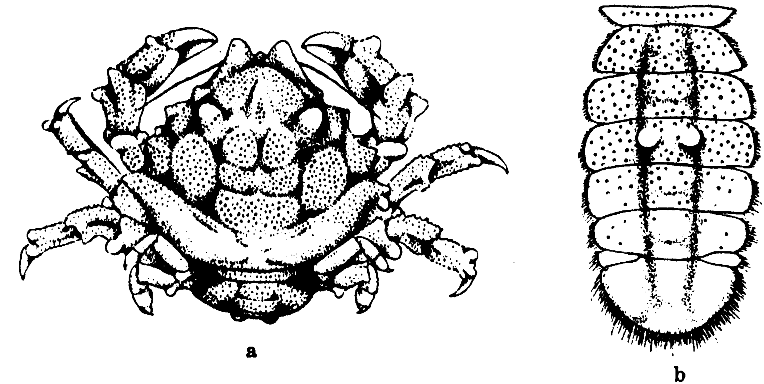
Distribution: Japan, Tokyo Bay, Sagami Bay, Kagosima Bay, Amakusa.

7. *Petalomera nodosa* sp. nov. Text-fig. 11.

The carapace is slightly broader than long, and sub-pentagonal; the regions are all elegantly defined and convex, thickly covered with

vesiculous granules excepting the posterior and postero-lateral surfaces. There is a smooth, high nodule on each protogastric region; the outer epibranchial region has also a high nodule, but it is entirely covered with vesiculous granules already mentioned.

The lateral frontal teeth are very prominent and rounded at the tip, covered with a few granules. The median frontal tooth is very small and is on a lower plane. There is no indication of pre- and postorbital teeth, the suborbital lobe is also very small. The true antero-lateral borders are armed with two small acuminate teeth, which are on a much lower plane.



Text-fig. 11. *Petalomera nodosa* sp. nov.

a. Dorsal aspect of type ♀. b. Abdomen of same.

(a, ×2; b, ×2.7.)

The postero-lateral tooth is most prominent of all the teeth of the lateral borders, the carapace being broadest at this point. The usual hepatic tubercle is very low and oblong, covered with vesiculous granules; below this, the two subhepatic tubercles can be observed on a line connecting the antero-lateral teeth with the antero-external angle of the buccal cavern, which is also armed with an indistinct tubercle.

The epimerons are imperfectly indurated.

The anterior three pairs of pereiopods are strongly nodular and covered with granules but the meri are not specially petaloid in shape. The arm of the chelipeds has two distal nodules on the upper and outer surfaces. The wrist is grooved on the upper surface, bearing two distal nodules, which are covered with granules. The palm has

only one small distal nodule. The inner surfaces of these segments are smooth.

The anterior two pairs of the ambulatory legs are equally stout, the ischium has a small nodule on the posterior margin. The merus has a smooth distal nodule at the end of the posterior border. The carpus has the upper surface channeled, the anterior and median extremities are armed respectively with a small nodule. The propodus bears two smooth nodules, one at the distal end of the anterior border and the other at the distal end of the upper surface. The dactylus is strongly curved; its posterior border bears four or five spinules. The third pair of the ambulatory legs is very small but stout. The arrangement of the nodules and granules resembles that in the anterior two pairs. The fourth pair of legs is slightly longer than the third pair but is more slender. The ischium is armed with a usual nodule, but the merus is unarmed, only granulated along the posterior border; the following segments are smooth.

The anterior five terga of the female abdomen are covered with granules. There is a pair of smooth nodules arranged side by side in the median line of the fourth tergum. The sixth and seventh terga are smooth.

The sternal sulci of the female are evidently different from the typical form of this genus, that is, they terminate in a pair of small processes, which are mounted on a low protuberance between the coxae of the first ambulatory legs.

The new species is akin to *Cryptodromia areolata* IHLE and also to *Cryptodromia gilesii* ALCOCK in the general appearance; it is, however, generically distinct from them on account of the presence of an epipodite on the coxae of the chelipeds.

The smooth nodules on either side of the gastric region and also on the fourth abdominal tergum are characteristic of this species.

Material examined: Type female, Tateyama Bay, obtained from a sandy bottom in 100 metres deep.

Measurements: Extreme length of carapace 15.5 mm, width 18 mm.

Genus *Conchoecetes* STIMPSON.

ALCOCK 1899, p. 150; 1901, p. 40; STIMPSON 1907, p. 180; IHLE 1913, p. 50.

This genus comprises only two species, of which the one restricted to India and Andaman Sea, and the other ranges widely in Indo-Pacific, from Cape of Good Hope to Japan.

Conchoecetes artificiosus (FABRICIUS). Pl. VIII, fig. 2.

ALCOCK 1899, p. 151 (list of earlier literature); 1901, p. 41; LAURIE 1906, p. 353; STIMPSON 1907, p. 180, pl. 21, fig. 5; BALSS 1922, p. 110; SAKAI 1934, p. 282; 1936, p. 34, text-fig. 3.

The whole surface of the body and appendages excepting the tips of the fingers is covered with a velvet-like tomentum. The carapace is quite flat, subpentagonal, with the regions fairly well defined. The front is cut into three obtuse teeth, the median one of which is small and on a much lower plane. The preorbital and suborbital teeth are equally prominent, while the postorbital tooth is quite rudimentary. There is a tooth on the lateral border immediately behind the cervical groove; the usual tooth behind the branchial groove is almost rudimentary, but in the Indian material, it seems also prominent (cf. ALCOCK).

There are two or three low tubercles on the subhepatic regions in the interval between the antero-lateral tooth and the antero-external angle of the buccal cavern; the surface between this row of tubercles and the orbit is studded with granules beneath the tomentum.

The chelipeds of the male are massive; the arm is prismatic, bearing a subdistal tubercle on the upper surface; its inner surface is smooth. The upper and lower borders of this segment are fringed with hairs, the former is granulated beneath the hairs. The wrist bears two distal nodules; its upper surface is sparsely granulated and the inner surface is provided with a tuft of hairs. The palm bears two terminal nodules, which are thickly covered with granules. The upper and outer surfaces are studded with pearly granules, which can be seen without denudation, the inner surface of this segment is tufted with longish hairs. The proximal surface of the movable finger is also covered with pearly granules already mentioned.

The anterior two pairs of the ambulatory legs are about equal in size. The meri of these legs are rather slender; their upper borders are studded with granules. The carpi have a tendency to be nodular at the distal end; the propodi and dactyli are unarmed. The third pair of the ambulatory legs are as stout as the anterior two pairs but are conspicuously shorter. The dactyli are large and talon-shaped, recurving upon a stout lobe at the proximal end of the posterior border of the propodus. The fourth pair of legs are very slender and short, the dactyli being very small and twisted.

In both sexes, the abdomen has a convexity along the middle line. The telson of the male is triangular in outline, that of the female is also triangular but much broader.

The sternal sulci of the female are subparallel in the anterior halves; they terminate in a pair of a low oblong processes, which are widely separated from each other in the interval between the coxae of the first ambulatory legs.

Material examined:

Coast of Odawara, Sagami Bay, 1 ♀, 1 ♂, Aug. 1932.
Onomiti M. B. S., 6 ♂♂, 1 ♀, Messrs. TAKI and KINOSITA.
Nagasaki, 1 ♀, Mr. I. KANEKO.

Measurements: Male from Onomiti, length of carapace in median line 26.5 mm, width 28 mm.

Habitat: Muddy bottoms, 30 to 100 metres deep.

Distribution: Japan (Sagami Bay, Kii Peninsula, Onomiti, Nagasaki), Hongkong, Siam, Ceylon, Coast of India, Persian Gulf, Queensland, Cape of Good Hope.

3 Family DYNOMENIDAE ORTMANN.

ALCOCK 1899, p. 127; 1901, p. 34.

Genus *Dynomene* LATREILLE.

ALCOCK 1899, p. 133; 1901, p. 35.

Key to the Japanese species of *Dynomene*.

1. Carapace broader than long, regions are marked obliquely by the hairs of different length. Orbital margins are spinulated. The five antero-lateral teeth are acuminated at the tip .... *D. hispida*.
2. Carace semiglobose, longer than broad and the regions marked by transverse grooves. Orbital margins are smooth and entire. The five antero-lateral teeth are obtuse .... *D. tanensis*.

1. *Dynomene hispida* DESMAREST. Pl. VIII, fig. 3.

M. EDWARDS 1837, H.N.C. II, p. 180; MIERS 1884, (Proc. Zool. Soc. London), p. 13; DE MAN 1887, p. 408; ORTMANN 1892, p. 543; ALCOCK 1901, p. 74; RATHBUN 1911, p. 195; IHLE 1913, p. 92 (in list); BALSS 1922, p. 105 (name only); YOKOYA 1933, p. 95, text-fig. 37.

The carapace is moderately convex and thickly covered with stiff hairs, the regions are fairly well defined. It is distinctly broader

than long, the proportion of length to breadth being as 14: 19. The front is broadly triangular, grooved in the middle line. The upper orbital margins are thick and oblique, bordered by two rows of stiff hairs; the surface along these margins are deeply canaliculated. The posterior and lower margins of the orbits are spinulated, but the spinules are concealed by the hairs. The antero-lateral borders are cut into five spiniform teeth, the last of which is very small.

The chelipeds are symmetrical; the ischium trigonal, the arm slightly longer than the ischium, its inner and lower surfaces are smooth but the upper border is covered with hairs, armed with a few sharp granules. The wrist armed with a stout tooth at its internal angle; the palm indistinctly granulated on the outer and upper surfaces, the granules are entirely concealed by rather long hairs; the lower and inner surfaces of this segment are smooth and glabrous. The moving finger is much longer than the immovable finger; both are hollowed at the tips, their prehensile edges are armed with one or two indistinct teeth, which are partly concealed by a few tufts of hairs.

The anterior three pairs of the ambulatory legs are equally very stout, the anterior borders of the arm, wrist and palm of these pairs are spinulated, but the spinules are entirely concealed by the marginal hairs. The last pair of the ambulatory legs is quite rudimentary, and is alone dorsal in position with the tips very minutely chelate.

The abdomen of the male is not exceedingly narrow in relation to that of the female; the telson of the male abdomen has the posterior margin triangular, but in the female it is obtusely rounded.

Material examined:

Okinosima in Tosa Bay, 3 ♀♀. 3 ♂♂, Prof. KAMOHARA. (In the Simoda M. B. S., there are also specimens from Hawaii- sent in exchange by Dr. EDMONDSON of the Bishop Museum, Honolulu.)

Measurements: Male from Tosa Bay, extreme length of carapace 14 mm, width, between the fourth antero-lateral teeth, 19 mm.

Habitat: Coral reefs or crevices of rock in 10 fathoms or so.

Distribution: Japan (Kii Peninsula (YOKOYA*), Tosa Bay (present paper), Asizuri-Zaki and Tanegasima (YOKOYA), Amami

* Dr. YOKOYA noted that his specimen was characterized by much obtuse antero-lateral teeth; in his figure the fifth antero-lateral teeth are figured as quite rudimentary. Our specimens belong to the typical form.

Ohsima (ORTMANN)); Mauritius; New Caledonia; Sandwich Isls.; Salomon Isls.; Coetivy; Hawaii.

2. *Dynomene tanensis* YOKOYA.

YOKOYA 1933, p. 96, text-fig. 38.

After YOKOYA, the carapace of this species is nearly semiglobose and proportionally longer than in the former species. The five antero-lateral teeth are very obtuse, while the orbital margins are smooth and entire. The upper surface of the carapace is marked by transeverse grooves. I have not yet had occasion to study this species.

Distribution: East of Tanegasima, 219 metres deep (YOKOYA).

4. Family HOMOLIDAE HENDERSON.

HENDERSON 1888, p. 18; ALCOCK 1901, p. 59; IHLE 1913, p. 52.

Key to the Japanese genera of the family Homolidae.

I. Carapace elongate-quadrangular or ovoid. Basal joint of eye-stalk usually very slightly longer than the terminal segment. Flagellum of antenna much longer than the carapace.
   1. Front dorsally compressed and bifid at tip. Preorbital spines not sensibly longer than the front. Second joint of antenna having its antero-external angle produced to from a spine .... *Homola.*
   2. Front a simple cylindrical spine. Preorbital spine prominent. Second joint of antenna not produced or specially acute at the antero-external angle .... *Homola* (*Parhomola*).

II. Carapace subquadrangular, basal joint of eye-stalk only slightly longer than the terminal segment. Flagellum of antenna much shorter than the carapace. Carapace and appendages are flattish .... *Homolomannia.*

III. Carapace elongate-quadrangular or piriform. Basal joint of eye-stalk much longer than the terminal joint. Flagellum of antenna shorter than the carapace.
   1. Carapace elongate-quadrangular. Flagellum of antenna relatively long. Abdomen consists of seven distinct segments in both sexes........... .... *Latreillopsis.*
   2. Carapace pyriform, its anterior portion forming a long neck. Flagellum of antenna short. Fourth to sixth abdominal segments fused together. .... *Latreillia.*

Genus *Homola* LEACH.

ALCOCK 1899, p. 154; 1901, p. 61; BALSS 1922, p. 111.

1. *Homola orientalis* HENDERSON. Pl. IX, fig. 1.

Homola orientalis HENDERSON 1888, p. 19, pl. 2, fig. 1; DOFLEIN 1902, p. 651, pl. 4, figs. 5-6.

Homola andamanica ALCOCK 1899, p. 156; 1901, p. 61, pl. 4, fig. 20; Illus. Invest. Crus., pl. 40, fig. 1.

Homola barbata orientalis, DOFLEIN 1904, p. 14, pl. 5, figs. 4-5; PARISI 1915, p. 109; BALSS 1922, p. 111; YOKOYA 1933, p. 99.

Homola orientalis, RATHBUN 1923, p. 143, pl. 37; SAKAI 1936, p. 35, pl. 3, fig. 2 (coloured).

The carapace is quadrilateral, distinctly longer than broad; its upper surface somewhat flat and the regions fairly well defined, its lateral surfaces deep and vertical. The whole surface except the tips of the tubercles and spines are covered with short but stiff hairs. The front depressed and is on a lower plane, it is longitudinally grooved and bifid at tip.

There are fifteen tubercles arranged symmetrically on the anterior surface of the carapace; of these, the two immediately behind the cervical grooves are most prominent and acuminate. There is a small but sharp tubercle behind each branchial groove and behind this a series of several small spinules. Inside and along this series of spinules, the linea homolica is distinct. The sub-orbital tooth is almost indistinct, but two small conical tubercles are found immediately behind it; the sub-hepatic region is armed with one strong and several small spiniform tubercles.

The basal segment of the eye-stalk is very slender, the distal segment being short and quadrate, bearing a reniform cornea. The flagellum of the antenna is much longer than the carapace. The external maxillipeds are subpediform, the ischium and merus being slender and narrow.

The chelipeds are stout and equal; the upper and lower borders of the arm bear a row of sharp spinules. The upper and outer surfaces of the wrist are spinulated and hairy, having a longitudinal groove on the upper surface. The palm unarmed, fingers not gaping and pigmented with light brown colouration.

The first three pairs of the ambulatory legs are subequal and compressed, the upper and lower borders of the meri are sharply spinulated, the posterior borders of the propodi and dactyli are also plumed with sharp spiniform bristles.

The fourth pair of the ambulatory legs alone is short and dorsal in position; the merus has three or four spinules on the posterior border and a terminal spine on the anterior border. The dactylus is claw-shaped and closes against the proximal spinules of the propodus. The second abdominal segment has a median spiniform tubercle.

Material examined:

Misaki, 2 ♀♀, 1 ♂, Mr. AOKI.
Manazuru in Sagami Bay, 8 ♀♀, 6 ♂♂, June 1935, "M'sago".
Between Ito and Hatusima, 2 ♀♀, 1 ♂, June 1935, "Misago".
Simoda, 2 ♀♀, 3 ♂♂, M. B. S.
Mimase, Tosa Bay, 1 ♂, Mr. MITIHIRO.

Measurements: Male from Sagami Bay, length of carapace 19 mm, width 15 mm.

Habitat: Sandy or muddy bottoms, 80 to 300 metres deep.

Distribution: Japan (Sagami Bay, Izu Peninsula, Kii Peninsula (YOKOYA), Tosa Bay), Philippine, Little Kei Isls., Sumatra, Andaman Sea.

Subgenus *Parhomola* WOOD MASON.

ALCOCK 1899, p. 156.

Key to the Japanese species of *Parhomola*.

1. A giant species, carapace measuring more than 120 mm long. Upper surface of carapace thickly covered with numerous sharp spinules. Meri of pereiopods covered with many spinules; chelipeds of male very stout and longer than any of the ambulatory legs .... *P. japonica.*
2. A species of medium size, carapace measuring less than 60 mm long. Upper surface of carapace armed with prominent spines of a symmetrical arrangement. Meri of pereiopods with a few spinules on both sides. Chelipeds of male not longer than the ambulatory legs .... *P. majora.*

1. *Homola (Parhomola) japonica* PARISI. Pl. III.

Parhomola japonica PARISI 1915, p. 109, pl. 3.
Parhomola cuvieri, BALSS 1921, p. 178 (nec. RISSO).

Parhomola japonica BALSS 1922, p. 111; YOKOYA 1933, p. 99 (nec. synonymy and distribution).
Latreillopsis hawaiiensis EDMONDSON 1932, p. 5, pl. 1, text-fig. 1.
Parhomola japonica, SAKAI, 1936, p. 35, pl. 2 (coloured).

A giant species, which is restricted to Japan and Hawaii.

The carapace is ovate-subquadrilateral, well calcified, the upper surface is deeply sculptured and covered with numerous spinules, of which those toward the anterior and lateral borders are very prominent. On either side of the uro-gastric, cardiac and intestinal regions, the surface is wrinkled. The linea homolica is distinct, beginning from the orbit to the posterior margin of the carapace.

The rostral horn is slender and short, projecting obliquely downwards. The preorbital spines are very prominent, projecting obliquely upward and are armed with a spinule on the lateral border above middle.

The spines on the lateral margins of the carapace, including those on the hepatic margins are very prominent and acuminate; two or three on the subhepatic regions are also very strong. The basal segment of the eye-stalk is slender and cylindrical, slightly thicker at the base, the distal segment being very thick and quadrangular. The basal segment of the antenna bears a strong quadrangular process, which rests against the epistome. The external maxillipeds are very long and sub-pediform, each segment is thickly furnished with brown setae along the inner border.

The abdomen of the male is distinctly seven-segmented, the first and second segments are very strongly constricted near the articulating line, the fourth to sixth segments are very broad; the terminal segment is elongate triangular. The chelipeds in the male are very strong and cylindrical; ischium, arm and wrist are covered with spiniform tubercles; palm is also tuberculated near the base, but the remaining surface is smooth.

The fingers are short, about half as long as the length of the palm, and are pigmented with deep black colouration. The anterior three pairs of the ambulatory legs are subequal, the meri are covered with spinules, of which those on the anterior border are strong, the anterior extremities of those segments are also armed with such a spine. The last pair of legs are reduced in size, but similar to the anterior pairs. The propodus has a few strong spinules at the proximal end of the posterior extremity, the horny tip of the dactylus folded back against these spinules.

Material examined: Inatori, Izu Peninsula, 1 ♂, Mr. TAGUTI.

Measurements: Length of carapace, 109 mm, width 92 mm, rostrum ? (broken off in the middle), cheliped 350 mm, third ambulatory leg 336 mm, fourth ambulatory leg 175 mm.

Habitat: Rocky bottom, 100 fathoms deep.

Type locality: Oiso, Sagami Bay (PARISI).

Distribution: Sagami Bay (PARISI, BALSS); Izu Peninsula (SAKAI); Tanegasima (YOKOYA); Hawaii (EDMONDSON).

2. *Homola (Parhomola) majora* (KUBO). Pl. IX, fig. 2.

Latreillopsis major KUBO 1936, p. 63, Pl. 17.

The carapace is subquadrilateral, thickly covered with flat pavement of knobbed setae. The rostrum slender, about one fourth as long as the carapace proper and projects anteriorly from a lower plane. The supraorbital spines are very prominent and direct obliquely upward, armed with a branch on the outer border a little beyond the middle.

The gastric region is armed with one median spine and four anterior spines in transeverse arrangement; in front and in the rear of this median spine, there are four tubercles, the two anterior are widely separated and the other two posterior are close together. The cardiac region is armed with two spinules arranged side by side; the branchial region has 10 or 11 spines of an unequal size, of these, the marginal three are very prominent. There is a low protuberance on the inner, posterior surface of this region near the intestinal region. The hepatic region is armed with five or six spines, of which the one at the upper anterior angle is the most prominent of all the spines on the upper surface of the carapace. The lateral vertical surfaces of the carapace are armed with several sharp tubercles. The antero-external angle of the buccal cavern in also armed with a prominent spine. The suborbital spine is strong, it is followed by a spinule just at the outer side of the basal segment of the antenna.

The eye-stalk is very slender and its terminal segment swollen, the cornea typically reniform. The antenna is very long, its extreme length exceeds that of the carapace; the second and third segments are unarmed. The external maxillipeds have the merus and ischium slender but they are somewhat operculiform, as they are broader than the following segments.

There is a tubercle at the inner extremity of the ischium and also at the inner border of the merus. Both the antero-external angles of these two segments are produced.

The abdomen seven-segmented in both sexes; the first four or five segments are provided with a median spine respectively. The spine at the posterior border of the penultimate segment is very prominent in the male, but rudimentary in the female.

The chelipeds are thin and slender, not exceeding the first three pairs of the ambulatory legs in length. The ischium is provided with a distal spine on the posterior border. The arm bears four spines on the posterior border. The wrist and palm are unarmed, the fingers are about two thirds as long as the palm and are pigmented with brown colouration. The first pair of the ambulatory legs is a little shorter than the following two pairs, which are subequal. In these three pairs, the upper borders of the coxa has a lamelliform projection, which is again terminated in two or three processes. The ischium is armed with two or three spines. The anterior border of the merus bears four or five spines, of which the terminal one is most prominent, while the posterior border of this segment bears nine or ten small spines, some of which are very often rudimentary. The carpus and propodus are unarmed, the latter is about twice as long as the former and is furnished irregularly with long hairs. The dactylus is most strongly compressed, its anterior and posterior borders are furnished with a row of spiniform setae. The fourth pair of the ambulatory legs is distinctly shorter than the anterior three pairs. The ischium is armed with a median spinule on the posterior border; the merius with a strong terminal spine on the anterior border but with no spines on both sides. The propodus is proximally very stout, armed with several slender spines at the proximal end of the posterior border, the tip of the dactylus fold back against these spines as usual.

The first three pairs of the pereiopods have an epipodite on the coxa, so that I referred this species to *Parhomola* instead of Latreillopsis of the original author. *Latreillopsis* and *Latreillia* are characterized by having no epipodite on any of the pereiopods.

Material examined:

Aziro, Izu Peninsula, 1 ♂, 1 ♀. The Aziro Primary School.
Koyawata in Sagami Bay, one specimen, broken, sex unknown, Mr. Y. YUZURIHARA.

Measurements: Male from Aziro, length of carapace in median line 30 mm, width 26 mm, rostrum 6.5 mm, supraorbital spine 10.5 mm, cheliped 74 mm, 1st ambulatory leg 106 mm, 2nd ambulatory leg 121 mm, 4th ambulatory leg 74 mm.

Habitat: Muddy bottom, 100–200 metres deep.

Type locality: Kominato in Tokyo Bay (KUBO).

Distribution: Tokyo Bay, Sagami Bay, Izu Peninsula.

Genus *Homolomannia* IHLE.

IHLE 1913, p. 74.

The unique species of this genus, *H. sibogae* IHLE was originally reported from the East of Kei Islands. In Japanese waters it seems not uncommon on muddy bottom of 50 to 100 fathoms deep.

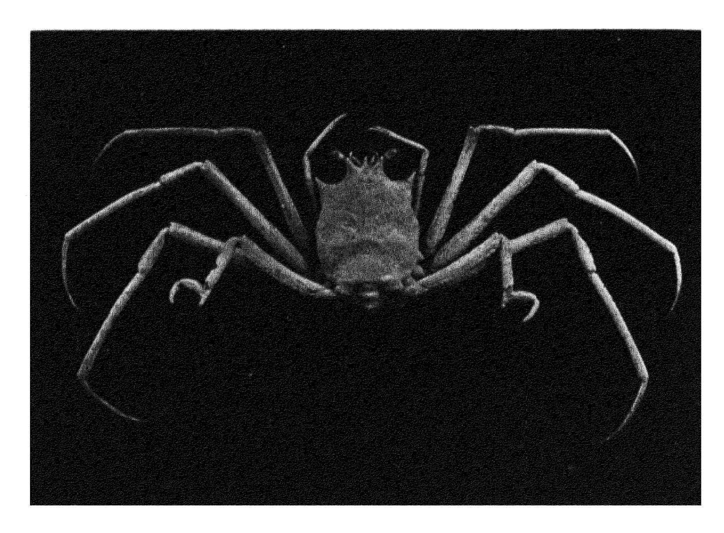
Homolomannia sibogae IHLE. Text-fig. 12.

IHLE 1913, p. 74, pl. 3, figs. 16–18; PARISI 1915, p. 113, text-figs. 1 (mouth parts) and 2 (pleopod of the male); BALSS 1922, p. 113; SAKAI 1936, p. 36, pl. 3, fig. 1 (coloured).

The whole surface of the body and appendages is thickly covered with a velvet-like tomentum. The carapace sub-quadrilateral, the upper surface is fairly well sculptured or wrinkled beneath the tomentum. The rostrum is very short, nearly one seventh as long as the rostrum and project almost horizontally. The hepatic regions are bulged, their external angles are terminated in a spine projecting obliquely outward and forward. The lateral borders of the branchial regions are convex.

The eye-stalks have the proximal segments rather thick and very slightly longer than the distal segment, which is quadrangular and a little depressed, bearing a sub-reniform cornea. The antenna has the basal three segments very slender, its flagellum short, not exceeding the total length of these three segments.

The chelipeds are much slenderer than any of the ambulatory legs; the segments have neither spines nor teeth. The first pair of the ambulatory legs is a little shorter than the next two pairs; the



Text-fig. 12. *Homolomannia sibogae* IHLE.
♀ from Tosa Bay. (× 3/4.)

merus, carpus, propodus and dactylus of these pairs are very flat and covered with velvet-like tomentum already mentioned. The fourth pair of legs are as stout as the anterior pairs but is exceedingly short. The proximal portion of the posterior border of the propodus bears a strong process, against which the falcate dactylus is folded.

The sternal sulci of the female are very short and widely separated from each other, terminating in a pair of low, laterally compressed protuberances in the interval between the coxae of the second ambulatory legs.

Material examined:

Manazuru in Sagami Bay, 1 ♀, 1932, Mr. TUYUKI.
Mimase, Tosa Bay, 1 ♀, 1 ♂, Prof. KAMOHARA; 1 ♀, 1 ♂, Mr. MITIHIRO.

Measurements: Female from Tosa Bay, length of carapace 29 mm, width of same 25 mm.

Habitat: Found on a muddy bottom, 50 to 100 fathoms deep.

Type locality: East of Kei Islands. (IHLE).

Distribution: Japan (Sagami Bay, Tosa Bay) and Kei Isls.

Genus *Latreillopsis* HENDERSON.

HENDERSON 1888, p. 21; ALCOCK 1899, p. 165; 1901, p. 72; EDMONDSON 1932, p. 3.

Key to the Japanese species of *Latreillopsis*.

I. Supraorbital spines simple, widely divergent at their tips. Hepatic spines very long and sharp. No other spines on the lateral border of the carapace, except the anterior branchial spine .... *L. bispinosa*.

II. Supraorbital spines subparallel with each other, bearing one to three branches on the lateral border. There is a small spinule on the lateral border a little behind the anterior branchial spine, which is very sharp .... *L. laciniata*.

1. *Latreillopsis bispinosa* HENDERSON. Pl. II, fig. 2.

HENDERSON 1888, p. 22, pl. 2, fig. 3; ALCOCK 1899, p. 166; 1901, p. 73, pl. 7, fig. 26; DOFLEIN 1902, p. 650, pl. 4, figs. 3, 4; IHLE 1913, p. 77; BALSS 1922, p. 115; YOKOYA 1933, p. 103; SAKAI 1934, p. 282,; 1936, p. 36, pl. 3, fig. 3 (coloured).

The carapace quadrilateral, the upper surface well sculptured and wrinkled. The gastric region bears three tubercles forming a triangle, one in the median line and the others a little anterior. The urogastric region wrinkled or indistinctly tuberculated. The cardiac region is irregularly protuberant, culminating in two tubercles placed side by side or almost confluent.

The linea homolica is distinct although its posterior half is indistinct. The rostrum short and acuminate, directing obliquely downward. The supraorbital spines nearly twice as long as the rostrum, directing obliquely upward and slightly outward. The hepatic regions very swollen, standing like little wings and are armed with two spines, the upper one of which is much longer. The foremost part of the branchial regions is a little swollen, terminating in an obtuse spine. Eye-stalks are a little shorter than the preorbital spines, their basal segments are very long and slender and the distal segments enlarged, bearing a reniform cornea.

The external maxillipeds have the ischium and merus operculiform, having no spines at all; the three terminal segments being very slender.

The chelipeds and ambulatory legs are slender, cylindrical and smooth. The merus is sparsely hairy on both sides, having a strong

terminal spine on the anterior border. The chela is very short, pigmented with brown colouration and is hardly as long as half of the length of the palm.

The fourth pair of the ambulatory legs is slender but longer than the chelipeds in both sexes, the propodus is specially enlarged at the base and is armed with several sharp spinules, against which the dactylus is folded.

Material examined:

Sagami Bay, at Manazuru, 5 ♀♀, 3 ♂♂, Oct. 1932, Mr. TUYUKI.
Kii Peninsula, Tatugahama, 1 ♂, Mr. Y. KUSE; off Wakayama, 1 ♀, 1 ♂, Mr. S. SAKAGUTI; Gobo, 1 ♀, 1 ♂, Mr. OKAMOTO.
Mimase, Tosa Bay, 2 ♀♀, 1 ♂, Prof. KAMOHARA; 1 ♀, 1 ♀, Mr. MITIHIRO.
Nagasaki, 1 ♀, 1 ♂, Mr. I. KANEKO.

Measurements: Male from Nagasaki, length of carapace 13.5 mm, width 12.2 mm, rostrum 3.5 mm, preorbital spine 6.5 mm, cheliped 35 mm, 2nd ambulatory leg 78 mm, last ambulatory leg 44 mm.

Habitat: Found on a muddy bottom, 30 to 100 fathoms deep.

Type locality: Zebu, Philippine (HENDERSON).

Distribution: Japan (Sagami Bay, Kii peninsula, Tosa Bay, Bungo strait (YOKOYA), Nagasaki); Philippine; Andaman (ALCOCK); Kei Isls. (IHLE).

2. *Latreillopsis laciniata* sp. nov. Pl. II, fig. 3; text-fig. 12.

This new species differs from *L. bispinosa* only in the following few points:—

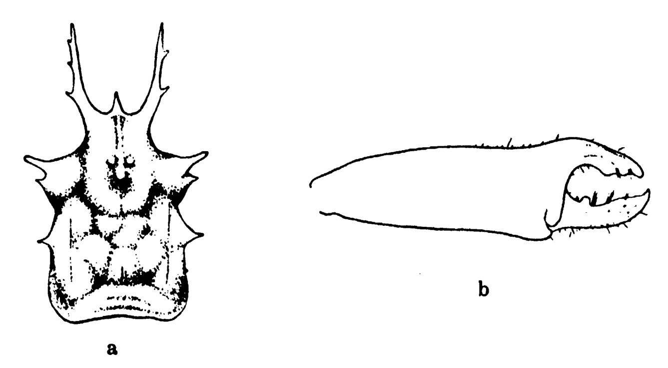
1. The carapace is relatively narrower and longer than in *bispinosa*, the ratio between width and length being 1:1.24; while in *bispinosa* it is 1:1.11.

2. The rostral horn is relatively shorter, it never exceeds one eighth the extreme length of the carapace.

3. The preorbital spines are less divergent than those of *bispinosa*, having two or three sharp branches on the outer border.

4. The hepatic regions are strongly produced, having one strong dorsal spine and three smaller ventral spinules, the former is much obtuse. There are two spinules on the lateral border of the carapace behind the hepatic lobe, the posterior one is much smaller.

5. Life colours of these two species resemble each other, but the type of the new species has the carapace and legs minutely flecked with red on yellowish ground.



Text-fig. 13. *Latreillopsis laciniata* sp. nov.

a. Outline of carapace of holotype. b. Chela of paratype.

(a, ×3 5; b, ×3.2.)

Material examined:

Simoda, male holotype, Oct. 1933.
Off Wakayama, male paratype, Mr. S. SAKAGUTI.

Measurements: Holotype, length of carapace 8 mm, width 6 mm, rostrum 1 mm, preorbital spine 4 mm, chelipeds 21 mm, 1st ambulatory leg 40 mm, last ambulatory leg 25 mm.

Paratype, length of carapace 13.4 mm, width 10 mm, rostrum 1.5 mm, preorbital spine 5.8 mm.

Habitat: Rocky shore, 15 fathoms deep.

Genus *Latreillia* ROUX.

ALCOCK 1898, p. 167; 1901, p. 70; BALSS 1922, p. 144.

This genus comprises only four species, viz.

L. elegans ROUX .... North Atlantic and Mediterranean Seas.
L. australiensis HENDERSON .... Australia.
L. phalangium DE HAAN .... Japan, endemic.
L. valida DE HAAN .... Japan, Indian Ocean.

The two Japanese species are distinguished as follows:—

1. **Supraorbital spines usually with three accessory spinules. The fourth ambulatory legs are subchelate ....** *L. phalangium.*
2. **Supraorbital spines simple. The fourth ambulatory legs are not chelate, the propodi being long and plumed on both sides and the dactyli very short and straight ....** *L. valiad.*

1. *Latreillia phalangium* DE HAAN. Pl. IV, fig. 1.

DE HAAN F. J. C. p. 108, pl. 30, fig. 2; ADAMS & WHITE 1850, p. 5; ORTMANN 1892, p. 542, pl. 26, fig. 2; DOFLEIN 1902, p. 649; PARISI 1915, p. 116; BALSS 1922, p. 114; URITA 1926, p. 2; YOKOYA 1933, p. 100; SAKAI 1934, p. 282; 1936, p. 37, pl. 4 (coloured).

The carapace is elongate-pyriform, the anterior portion prolonged to form a long neck and the branchial regions do not perfectly cover the basal joints of the walking legs. In the median line of the carapace, there is a spine a little behind the middle of the neck. The cardiac region is protuberant but with neither tubercle nor spine. There is no linea homolica on either side of the carapace. The lateral borders of the carapace have a submedian spine. There is a conspicuous spine on the hepatic region near the antero-external corner of the buccal frame.

The rostral spine is very slender and acuminate. The preorbital spines are very long and widely divergent, usually having three accessory spinules: the first or proximal one is on the ventral side, the second on the outer border and the third on the upper surface.

The eye-stalks are distinctly shorter than the preorbital spine; their basal segment is very long and slender, while the distal segment is short and enlarged, bearing a reniform cornea. The external maxillipeds are subpediform, the merus is armed with a strong spine on the external surface.

The chelipeds are shorter than the anterior three pairs of the ambulatory legs. The arm spinulated; the wrist slender and smooth; the palm swollen and the chelae compressed, the prehensile edges of the fingers are entire and not gaping.

The anterior three pairs of the ambulatory legs are subequal; the merus armed with numerous spines, of which the terminal one on the anterior border is most prominent, while those on the posterior border are smaller. The carpus unarmed, the porpodus enlarged at the end and furnished with a few distal spinules on the posterior

border. The dactylus is very indistinctly falcate at the tip. The merus of the last ambulatory legs is armed with strong spines on the posterior border, the carpus unarmed, the propodus much shorter than the carpus and is enlarged near the apex, which is furnished with a few strong setae, against which the short but falciform dactylus is folded.

The abdomen of the male consists of seven distinct terga; that of the female of five, the fourth to sixth terga being fused together. The first three terga of the female abdomen have a median spinule, the third being most prominent and acute; in the case of the male abdomen, they have none. There is an additional spine on either side of the fourth and fifth terga of the female abdomen.

Material examined:

In the Simoda M. B. S. are many specimens from Tokyo Bay, Sagami Bay, Simoda, Ise Bay, Kii-peninsula and Nagasaki.

Measurements: Male from Tokyo Bay, length of carapace 12 mm, width 8 mm, rostrum 2 mm, preorbital spine 6 mm, cheliped 50 mm, first ambulatory leg 82 mm, last ambulatory leg 37 mm.

Habitat: Found on sandy or muddy bottoms, 50 to 300 metres deep.

Distribution: Japan, endemic. After YOKOYA, this species ranges from Aomori Bay to Kyusyu.

2. *Latreillia valida* DE HAAN. Pl. IV, fig. 2.

DE HAAN F. J. C. p. 107, pl. 30, fig. 1; DOFLEIN 1902, p. 649; RATHBUN 1902, p. 32; IHLE 1913, p. 81; BALSS 1922, p. 114; YOKOYA 1933, p. 102; SAKAI 1934, p. 282; 1936, p. 37, pl. 5 (coloured).

Syn.: *Latreillia pennifera* ALCOCK 1899, p. 168; 1901, p. 71, pl. 7, fig. 27; RATHBUN 1911, p. 196; IHLE 1913, p. 82.

This species can easily be distinguished from the former species in the following series of characters:

1. The carapace has no other spines except one in the median line of the "neck". The hepatic regions have a strong bulge and the cardiac region is indistinctly trituberculated.

2. The preorbital spines are relatively shorter and have no accessory spinules. The eye-stalks are nearly as long as the preorbital spines.

3. The chelipeds and ambulatory legs are elegantly cross-banded with red and white. The fourth ambulatory legs are not chelate; the propodi are plumed on both sides, resembling the vane of a feather; the dactyli are extremely short.

4. The first two terga of the male abdomen have a median spine, while in the case of the female, the third tergum also bears a median prominent spine; beside these, the fourth tergum of the female has a sharp spine on either side.

Material examined:

In the Simoda M. B. S. are many specimens from Tokyo Bay, Sagami Bay, Simoda, Ise Bay, Kii Peninsula, and Tosa Bay.

Measurements: Male from Sagami Bay, length of carapace 16 mm, width 11.5 mm, rostrum 3 mm, preorbital spine 4.5 mm, cheliped 77 mm, first ambulatory leg 137 mm, last ambulatory leg 88 mm.

Habitat: Found on sandy or muddy bottoms, 50 to 250 metres deep.

Distribution: Japan (South of Tokyo Bay to Kyusyu; on the continental side, this species ranges northward to Niigata (YOKOYA)); Philippine (BALSS); Saya de Malha, Seychelles (RATHBUN); Kei Isls. (IHLE); Bay of Bengal, Bay of Martaban, Mergui Archipelago (ALCOCK).

IV. Remarks on habitat, habit and distribution

The members of the Subtribe DROMIACEA found in Japanese waters number 34 species and two subspecies in all, distributed among 14 genera and four families; of these five species and two subspecies were referred to as new to science and together with the other five species, are recognized to be endemic to Japan.

They are all marine; we can find neither fresh water nor even estuarine members. Of the four families comprised in this subtribe, Homolodromiidae and Homolidae are mostly deep water inhabitants, while in Dromiidae and Dynomenidae, some are pecular to a showl water but some descend to a considerable depth. As a characteristic for the littoral inhabitants, their habitat is restricted to hard beaches, namely to rocky or stony shores; none of them inhabit the shifting beaches, namely on muddy or sandy shores. As the depth increases,

the rocky, sandy or muddy grounds are equivalent for each peculiar inhabitant.

It is one of the most important characters of Dromiacea that one or both of the posterior pairs of feet are reduced in size and chelate, deviating to the dorsal side. For the most part, the members of the family Dromiidae are in the habit of carrying on their back a mass of compound Ascidians or shore sponges with the aid of these reduced or prehensile legs.

It is generally noticed that the crab does not confine its choice to a definite animal to carry. For the purpose of making sure of this habit, the author reared a number of *Petalomera fukuii* mihi in captivity. This species is very common on the rocky or stony beaches in the vicinity of Simoda and its partner is almost always confined to *Botrylloides* or *Reniella* of various colourations. The data of this experiment shows, though vaguely, that the crab select the partner animals by chance; the kinds or colourations of the partner animals seem not to be connected with the taste of the crab.

The distribution of the Japanese species of Dromiacea is summarized in the following table:—

Table 1. The distribution of Japanese Dromiacea.

(The Japanese endemic species are marked with an asterisk.)

Localities. / Families and Species.			Japan, Pacific side.											Japan, continental side.								
	Hakodate	Mutu Bay	Sendai	Tokyo Bay	Sagami Bay	Izu Peninsula	Suruga Bay	Ise Bay	Kii Peninsula	Tosa Bay	Onomiti	Miyazaki-ken	Kagosima	North	Middle	South	Nagasaki	Amakusa	Ohsima	Loo Choo	Formosa	Bonin Isls.	Foreign countries.
HOMOLODROMIIDAE																							
**Dicranodromia döderleini.*	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	
DROMIIDAE																							
Dromia dehaani.	+	·	·	+	+	·	·	+	+	+	·	·	+	·	+	·	+	·	·	·	·	·	Hongkong, Java, Indian Ocean, Gulf of Aden.
D. intermedia.	·	·	·	+	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	Ceylon, Indian Archipelago.
Dromidiopsis dormia.	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	Hawaii, South Sea, Ternate, Amboina, Red Sea, Mozambique, Cape of good Hope.
D. cranioides.	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	Mergui Archipelago, Andaman Sea, Singapore, Siam, Java Sea, New Guinea.
Dromidia unidentata.	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	Red Sea, East coast of Africa, Indian Ocean.
Sphaerodromia kendalli.	·	·	·	·	·	+ Nii-zima	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	Bay of Bengal.
Cryptodromia tuberculata.	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	+	·	·	·	Coast of India.

Table 1.—(*Continued*)

Localities. / Families and Species.			Japan, Pacific side.											Japan, continental side.									
	Hakodate	Mutu Bay	Sendai	Tokyo Bay	Sagami Bay	Izu Peninsula	Suruga Bay	Ise Bay	Kii Peninsula	Tosa Bay	Onomiti	Miyazaki-ken	Kagosima	North	Middle	South	Nagasaki	Amakusa	Ohsima	Lco Choo	Formosa	Bonin Isls.	Foreign countries.
C. tumida typica.	·	·	·	·	+?	·	·	·	+	·	·	+	+	·	·	·	·	·	+	+	·	·	Malay Archipalago, Western Australia.
**C. tumida bispinosa.*	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	
**C. tumida trispinosa.*	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	
**C. nipponensis.*	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	+ Goto	·	·	·	·	·	
C. bullifera.	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	Ceylon, coast of India.
C. canaliculata.	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	+ Ki-kai sima	+	·	·	Gaspar str., India, Red Sea, East Coast of Africa.
C. coronata.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	Amboina, Samoa, Coast of India.
C. incisa.	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	Twofold Bay.
C. areolata.	·	·	·	·	+	·	·	·	·	+	·	+	·	·	·	·	+	·	·	·	·	·	Timor Isls.
**Petalomera angulata.*	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	

Table 1.—(*Continued*)

Families and Species. / Localities.	Hakodate	Mutu Bay	Japan, Pacific side.											Japan, continental side.			Nagasaki	Amakusa	Ohsima	Loo Choo	Formosa	Bonin Isls.	Foreign countries.
			Sendai	Tokyo Bay	Sagami Bay	Izu Peninsula	Suruga Bay	Ise Bay	Kii Peninsula	Tosa Bay	Onomiti	Miyazaki-ken	Kagosima	North	Middle	South							
**P. fukuii.*	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	
P. lateralis.	·	·	·	·	·	—— Madsica sima? ——								·	·	·	·	·	·	·	·	·	Australia, New Zealand.
**P. atypica.*	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	
P. wilsoni.	·	+	·	·	+	+	+	·	+	+	·	·	+	+	+	+	·	·	·	·	·	·	
P. japonica.	·	·	+ Iwate-ken	+	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	Funafuti.
P. granulata.	·	·	·	+	+	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·	·	Hongkong.
**P. nodosa.*	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	
Conchoecetes artificiosus.	·	·	·	·	+	·	·	·	+	·	+	·	·	·	·	·	+	·	·	·	·	·	Hongkong, Siam, India, Ceylon, Persian Gulf, Cape of Good Hope, Queensland.
DYNOMENIDAE																							
Dynomene hispida.	·	·	·	·	·	·	·	·	+	+	·	·	+ Tane Is.	·	·	·	·	·	·	·	·	·	Hawaii, Sandwich Isls., New Caledonia, Indian Ocean.
**D. tanensis.*	·	·	·	·	·	·	·	·	·	·	·	·	+ Tane Is.	·	·	·	·	·	·	·	·	·	

Table 1.—(*Continued*)

Families and Species. / Localities.	Hakodate	Mutu Bay	Sendai	Japan, Pacific side. Tokyo Bay	Sagami Bay	Izu Peninsula	Suruga Bay	Ise Bay	Kii Peninsula	Tosa Bay	Onomiti	Miyazaki-ken	Kagosima	Japan, continental side. North	Middle	South	Nagasaki	Amakusa	Ohsima	Loo Choo	Formosa	Bonin Isls.	Foreign countries.
HOMOLIDAE																							
Homola orientalis.	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	Andaman Sea, Kei Isls., Australia, Philippine.
H. (Parhomola) japonica.	.	.	.	.	+	+	.	.	.	.	.	.	+ Tane Is.	.	.	.	.	.	.	.	.	.	Hawaii—.
**H. (Parhomola) majora.*	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Homolomannia sibogae.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	Kei Islands.
Latreillopsis bispinosa.	.	.	.	.	+	+	.	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	Andaman Sea, Coast of India.
**L. laciniata.*	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	
**Latreillia phalangium.*	.	+	.	+	+	+	+	+	+	+	.	+	+	+	+	+	+	+	.	.	.	.	
L. valida.	.	+	.	+	+	+	.	+	+	+	.	.	+	+	+	.	+	+	.	.	.	.	Indian Ocean.

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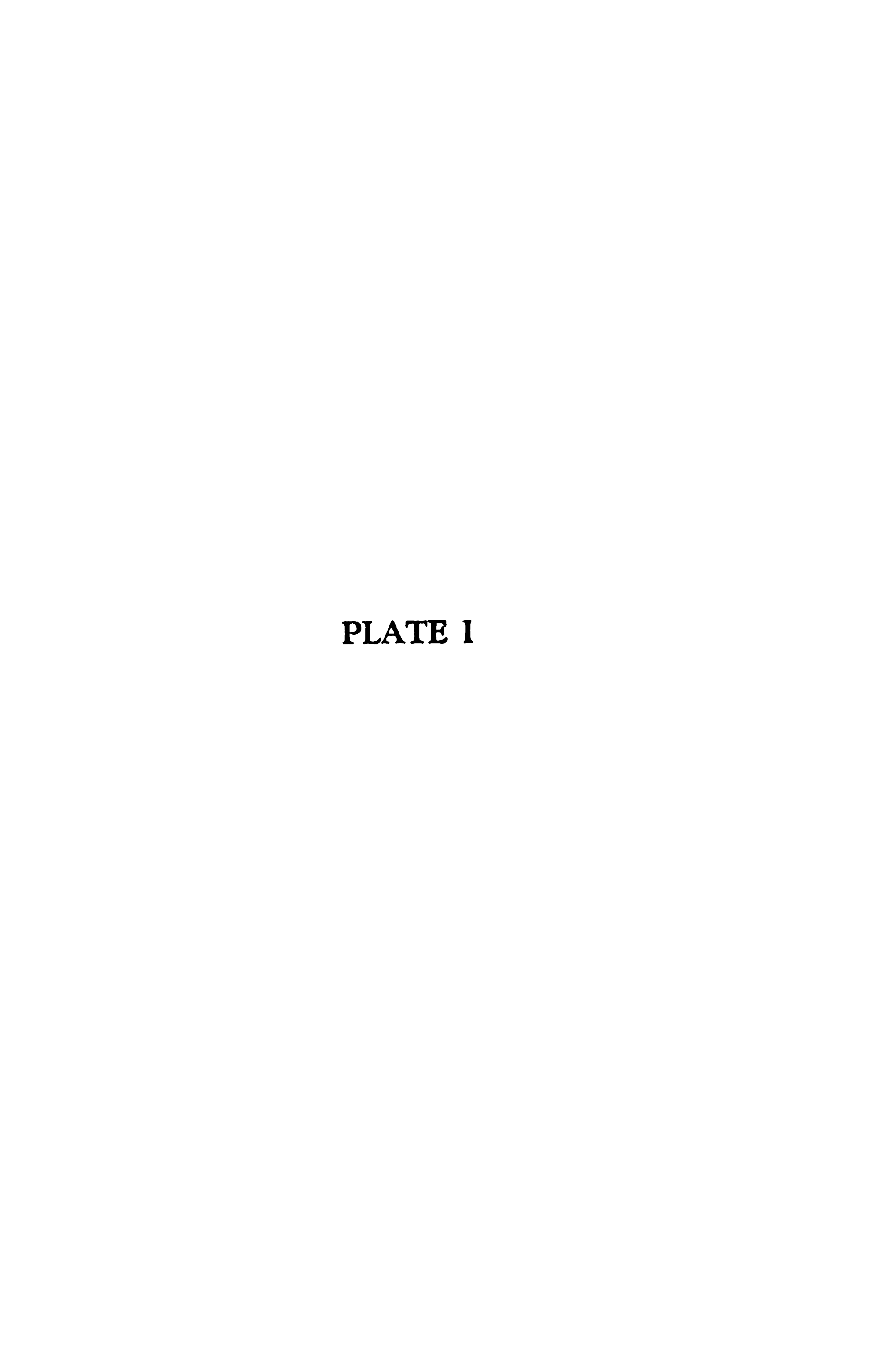


PLATE I

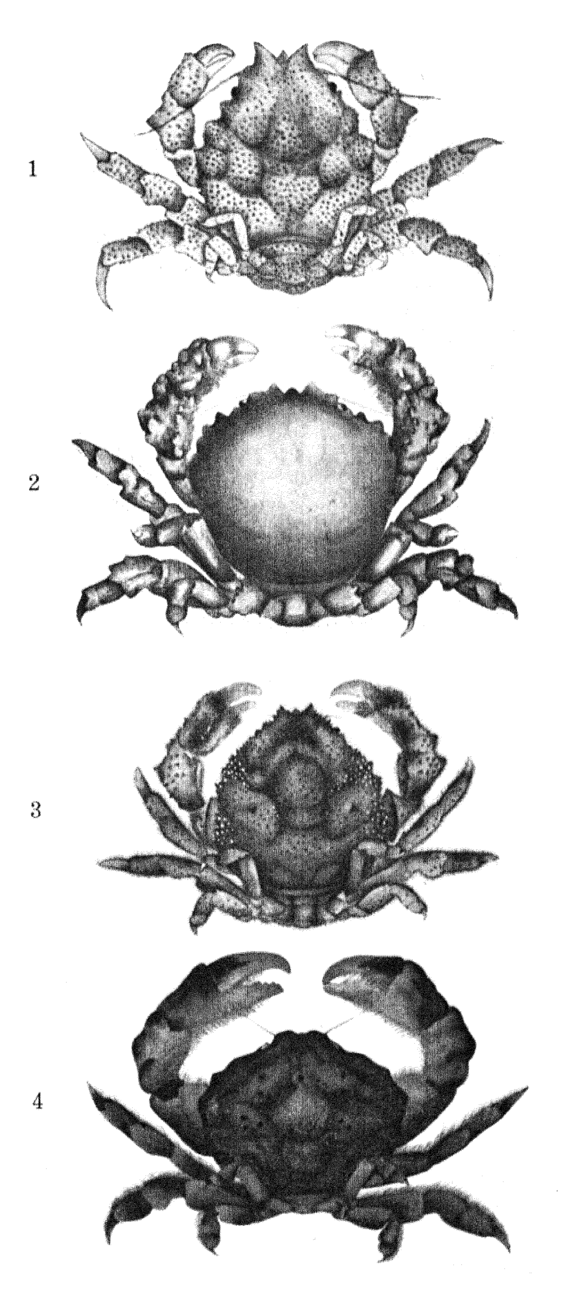
Explanation of the Plate I

Fig. 1. *Cryptodromia areolata* IHLE. ♀ from Sagami Bay, ×4.5.

Fig. 2. *Petalomera fukuii* sp. nov. Type ♂, ×2.5.

Fig. 3. *Petalomera granulata* STIMPSON. ♂ from Tokyo Bay, ×1.

Fig. 4. *Petalomera wilsoni* (FULTON & GRANT). ♂ from Simoda, ×1.



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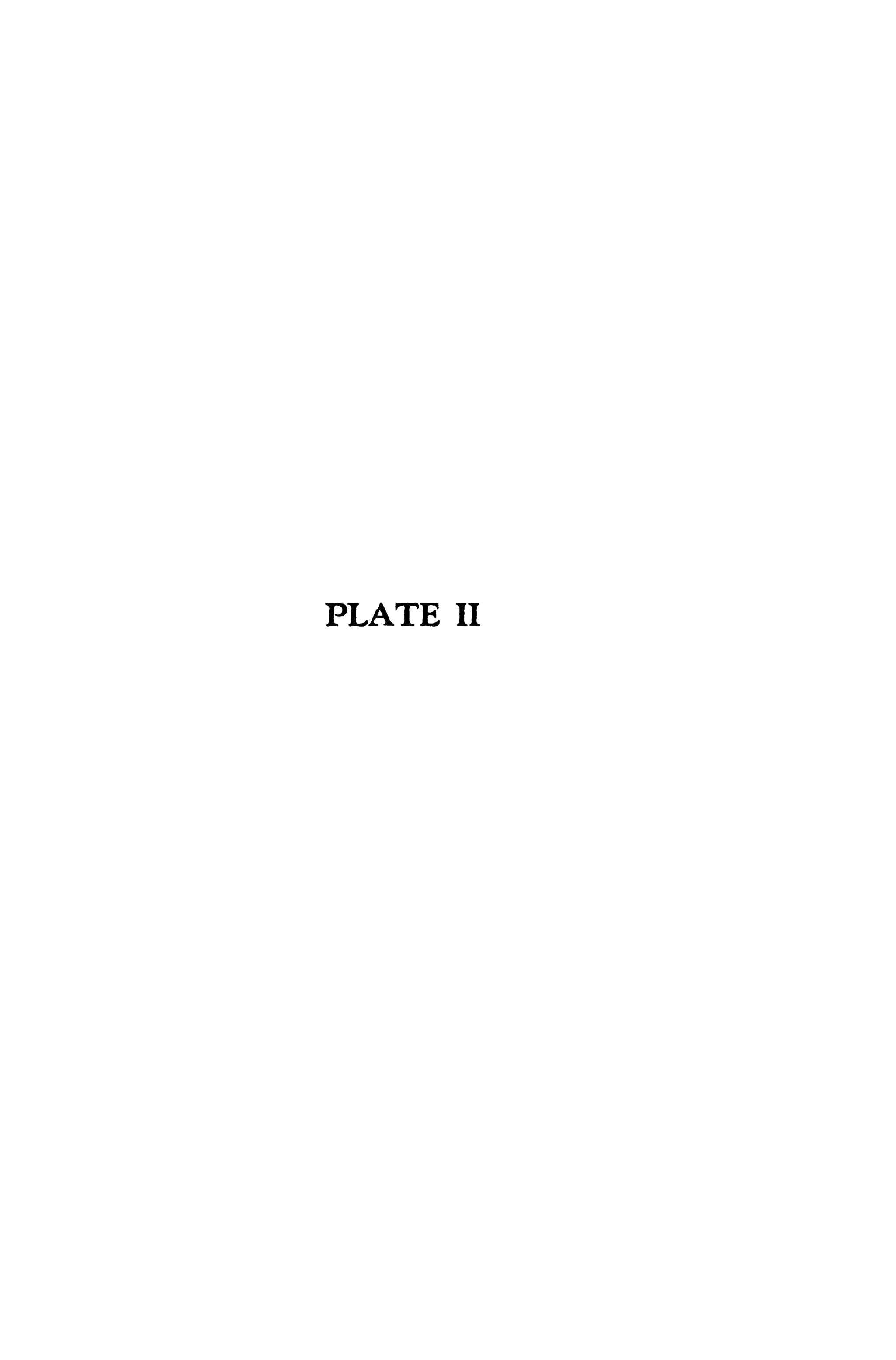


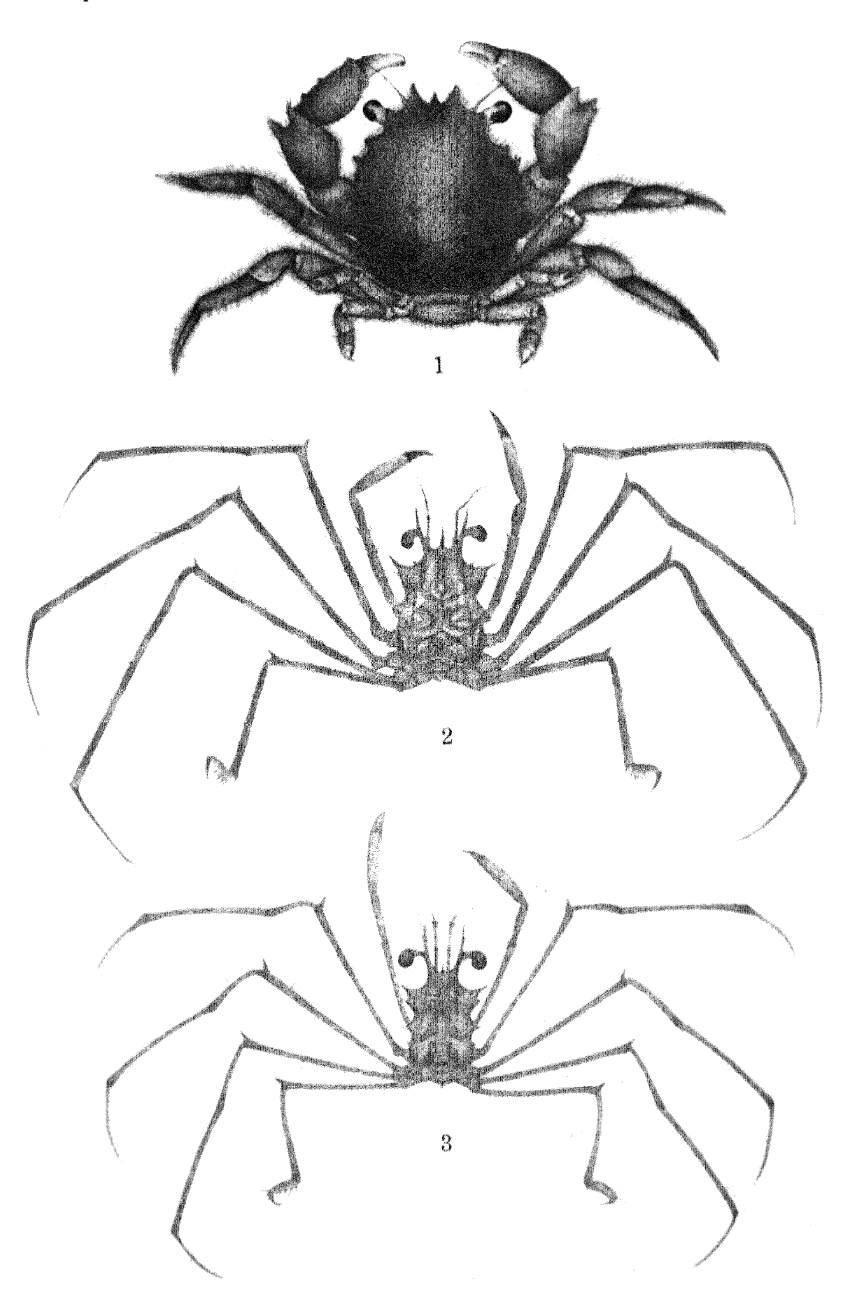
PLATE II

Explanation of the Plate II

Fig. 1. *Petalomera atypica* sp. nov. Type ♂, ×4.5.

Fig. 2. *Latreillopsis bispinosa* HENDERSON. ♂ from Sagami Bay, ×1.

Fig. 3. *Latreillopsis laciniata* sp. nov. Type ♂, ×1.8.


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2
3

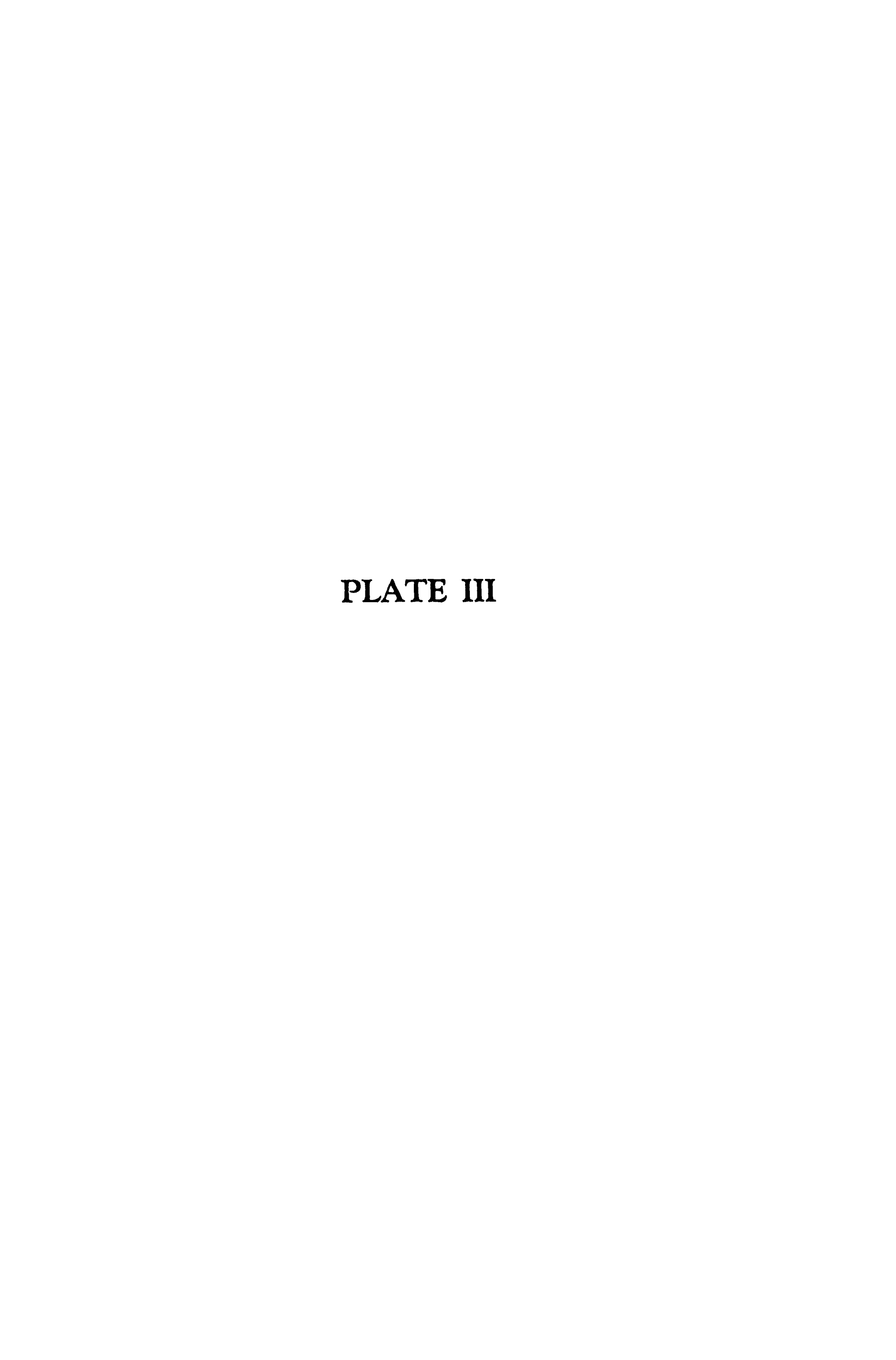
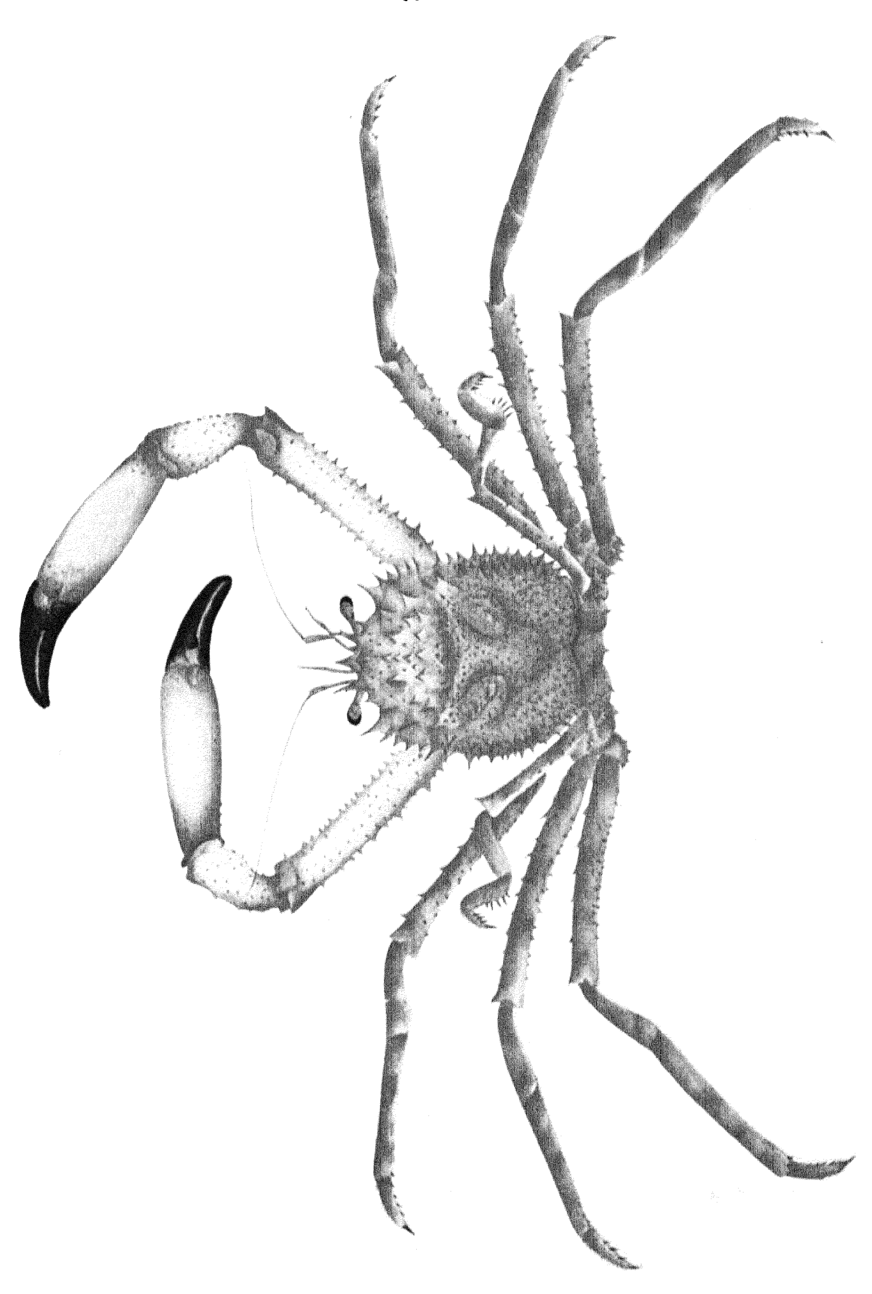


PLATE III

Explanation of the Plate III

Homola (Parhomola) japonica PARISI. ♂ from Izu Peninsula, ×1/3.



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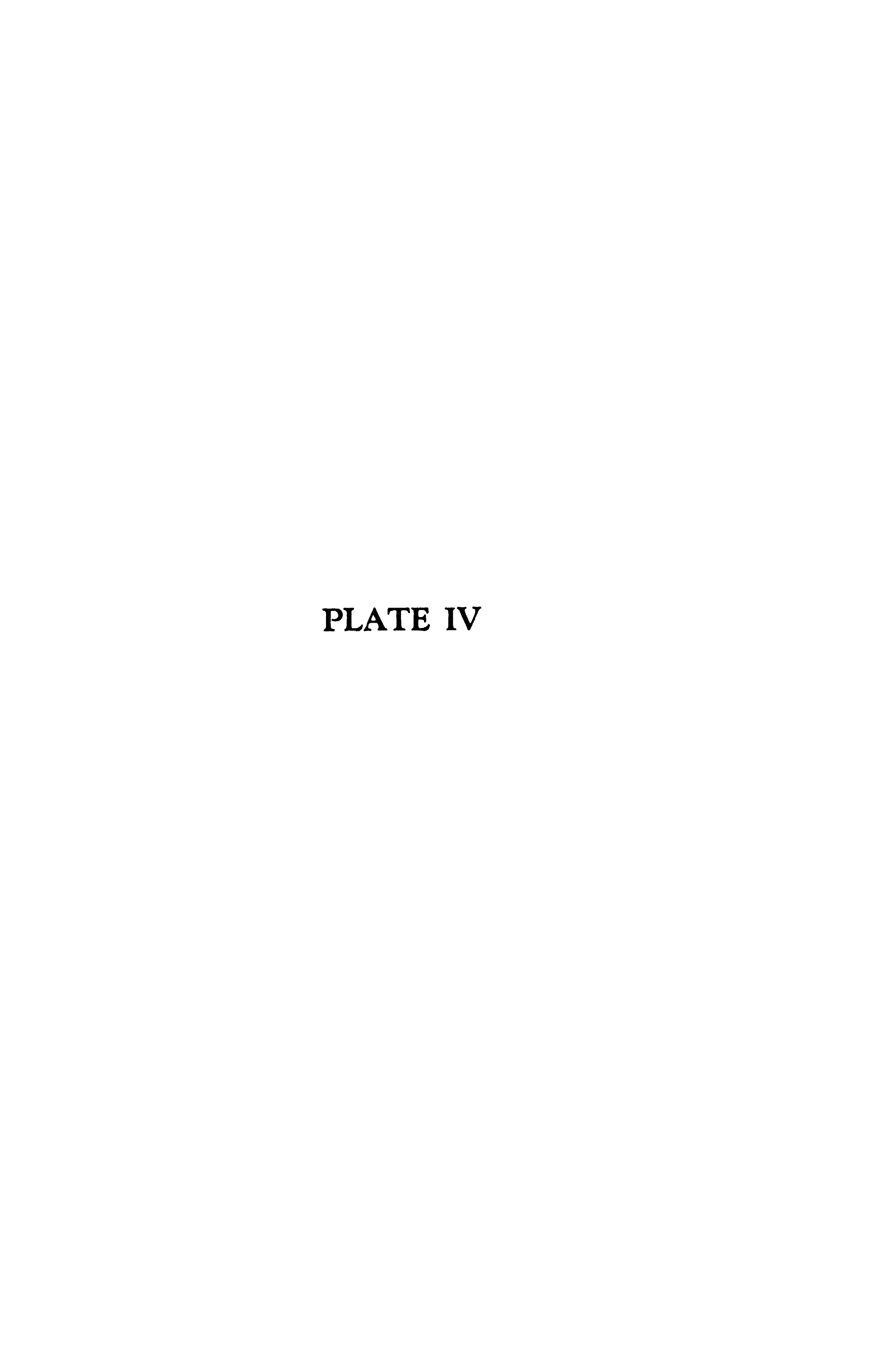
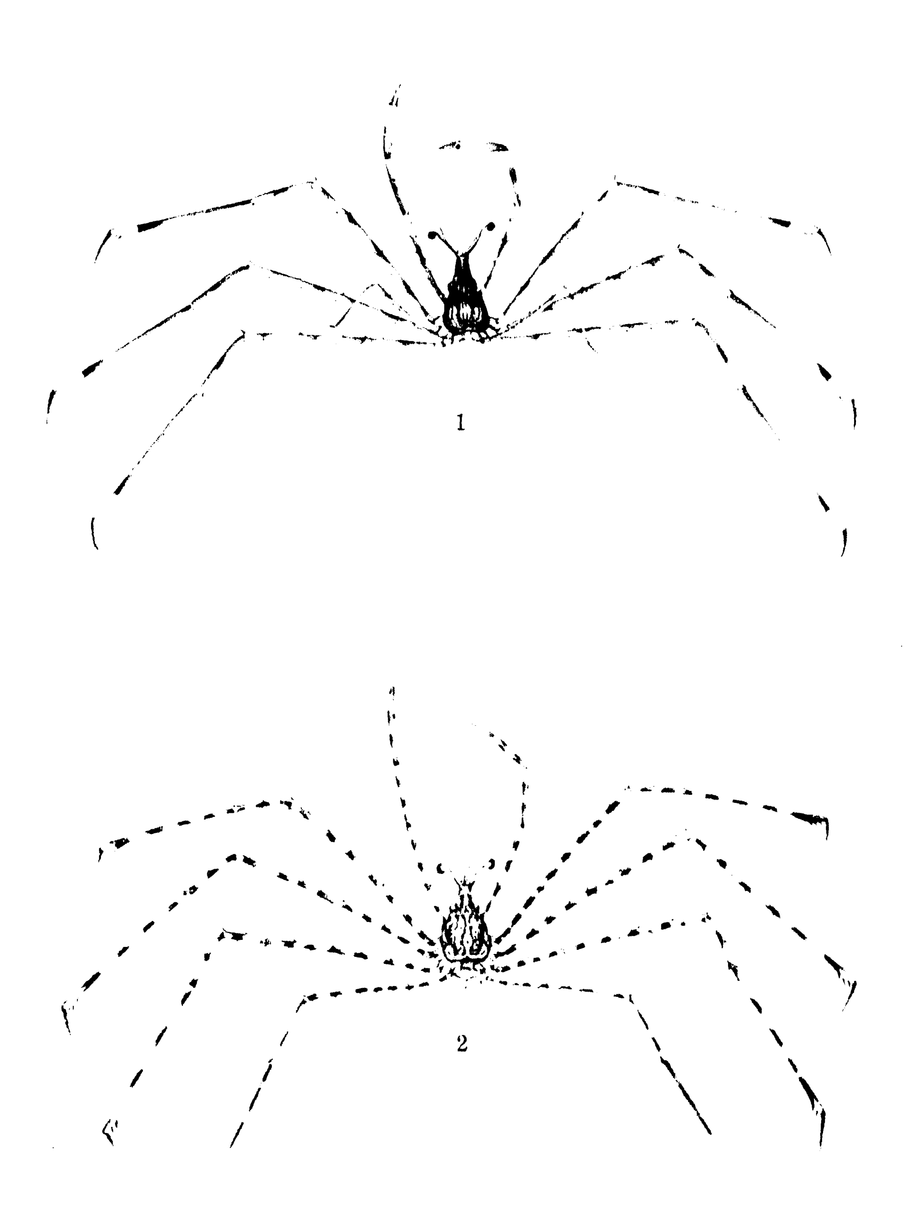


PLATE IV

Explanation of the Plate IV

Fig. 1. *Latreillia phalangium* DE HAAN. ♂ from Simoda, $\times 1$

Fig. 2. *Latreillia valida* DE HAAN. ♂ from Sagami Bay, $\times {}^{4}/_{5}$


1
2

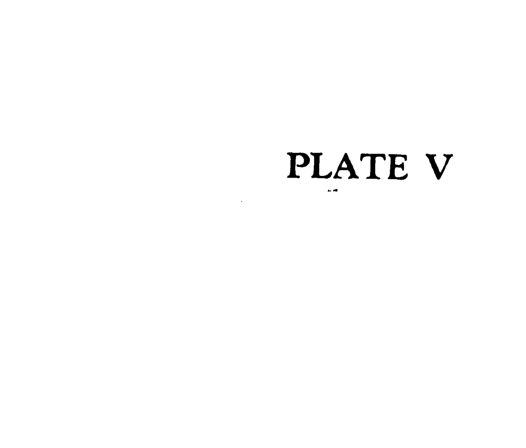


PLATE V

Explanation of the Plate V

Fig. 1. *Dromia dehaani* RATHBUN. ♂ from Sagami Bay, ×2/3.

Fig. 2. *Dromidiopsis dormia* (LINNAEUS). ♂ from Seto M. B. L., ×1/2.



1

2

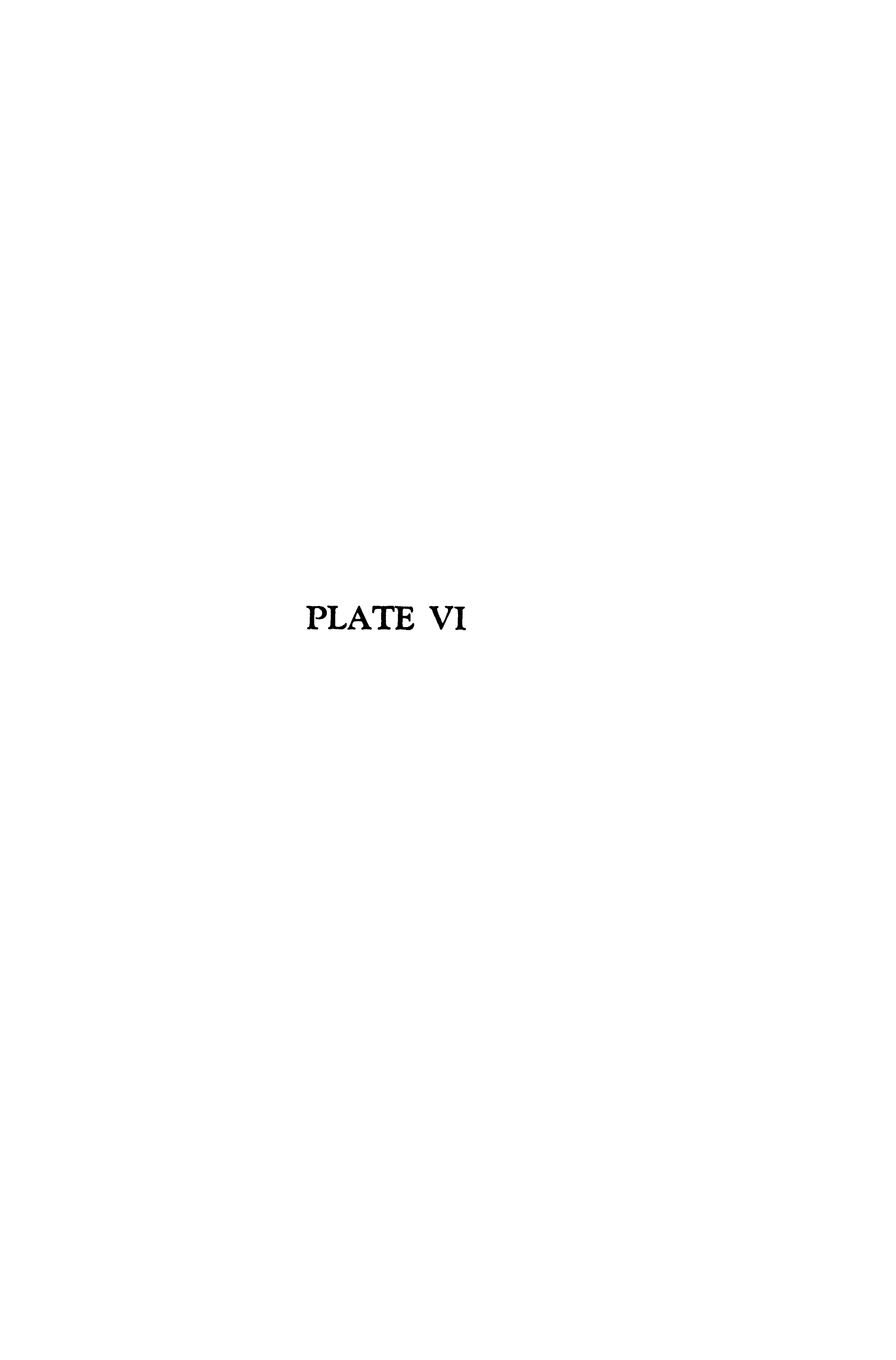


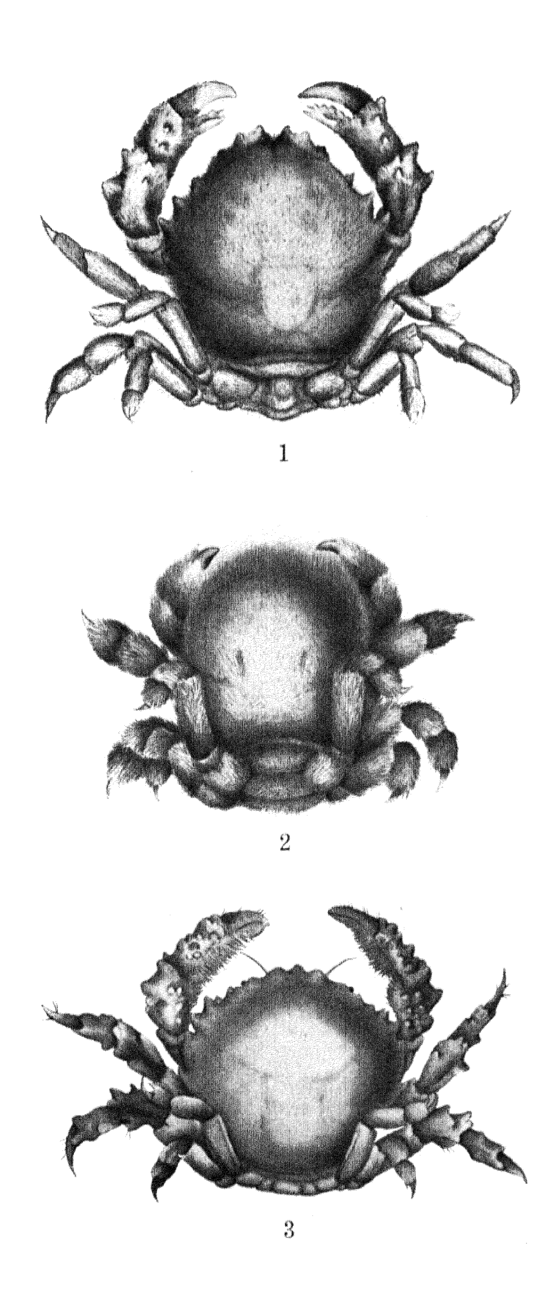
PLATE VI

Explanation of the Plate VI

Fig. 1. *Dromia intermedia* LAURIE. ♂ from Tokyo Bay, ×1.

Fig. 2. *Dromidia unidentata* (RÜPPELL). ♂ from Kii Peninsula, ×1.

Fig. 3. *Cryptodromia tvberculata* STIMPSON. ♂ from Seto M. B. L., ×3.1.


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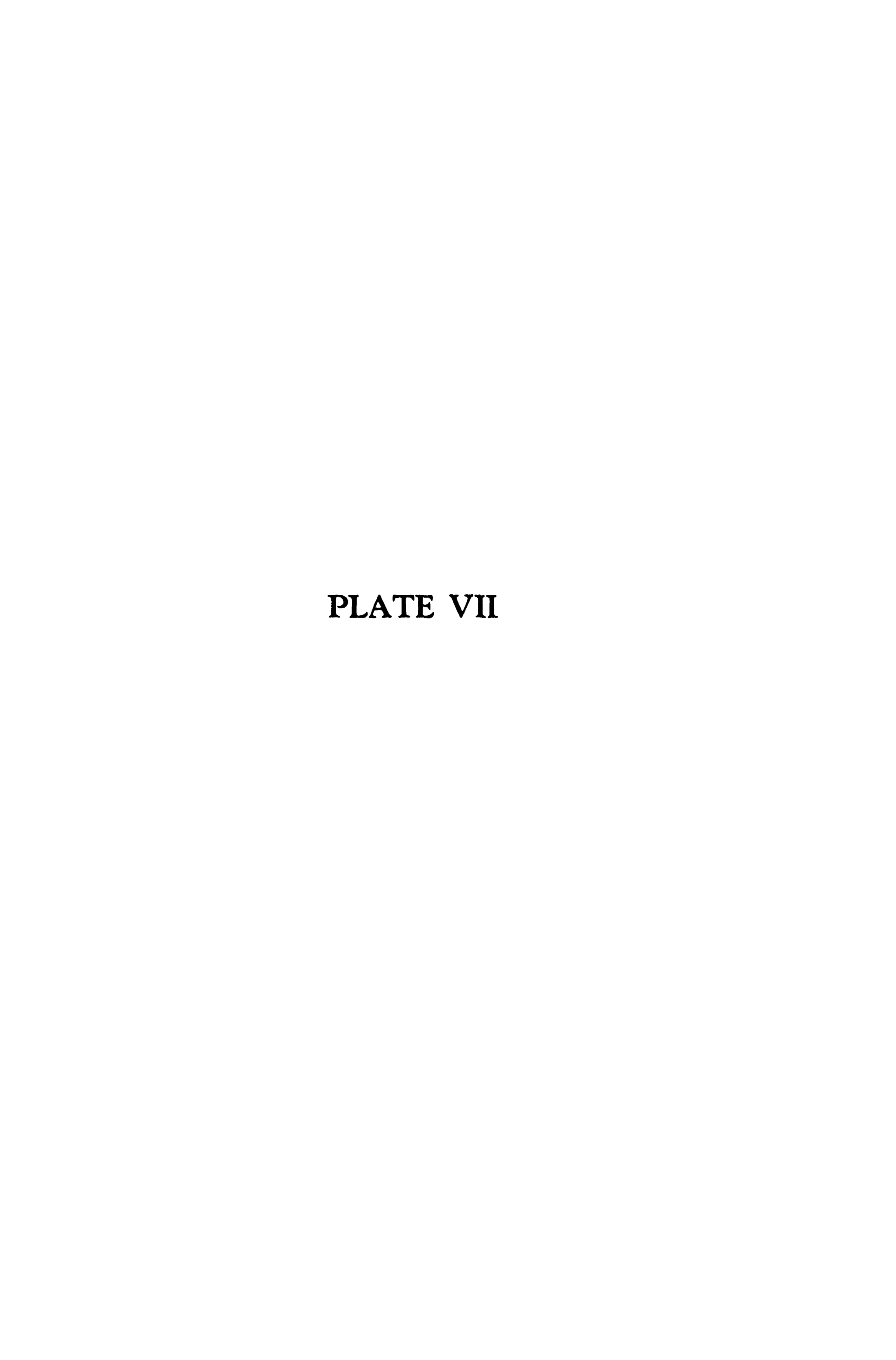


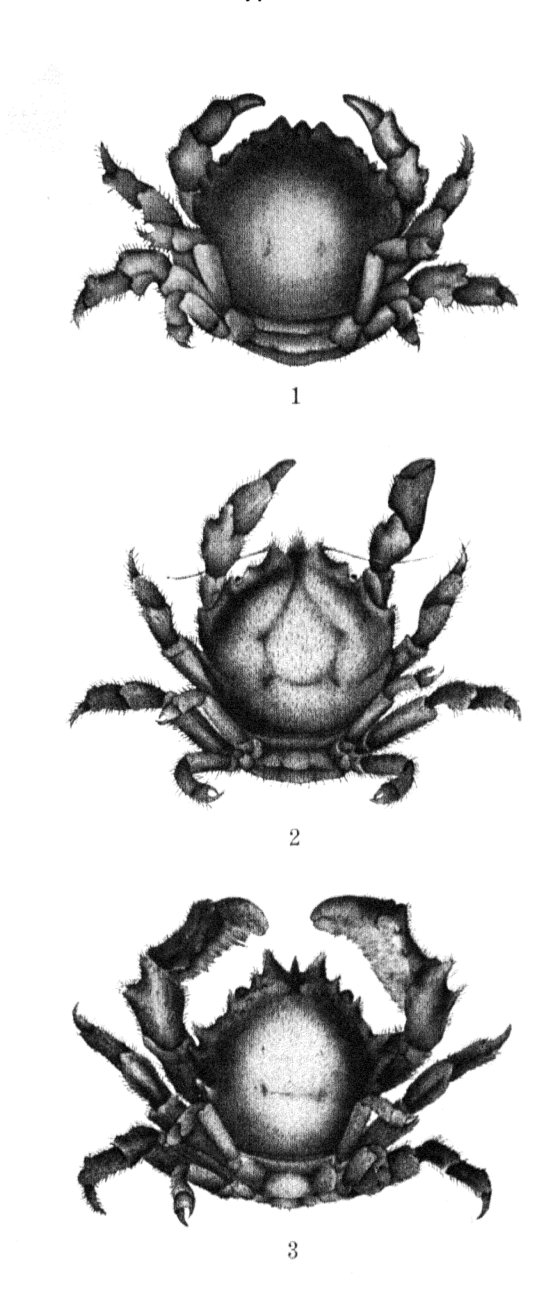
PLATE VII

Explanation of the Plate VII

Fig. 1. *Cryptodromia tumida typica* (STIMPSON). ♀ from Wakayama, ×5.

Fig. 2. *Cryptodromia canaliculata* STIMPSON. ♂ from Wakayama, ×5.5.

Fig. 3. *Cryptodromia bullifera* ALCOCK. ♂ from Kii Peninsula, ×2.7.



1

2

3

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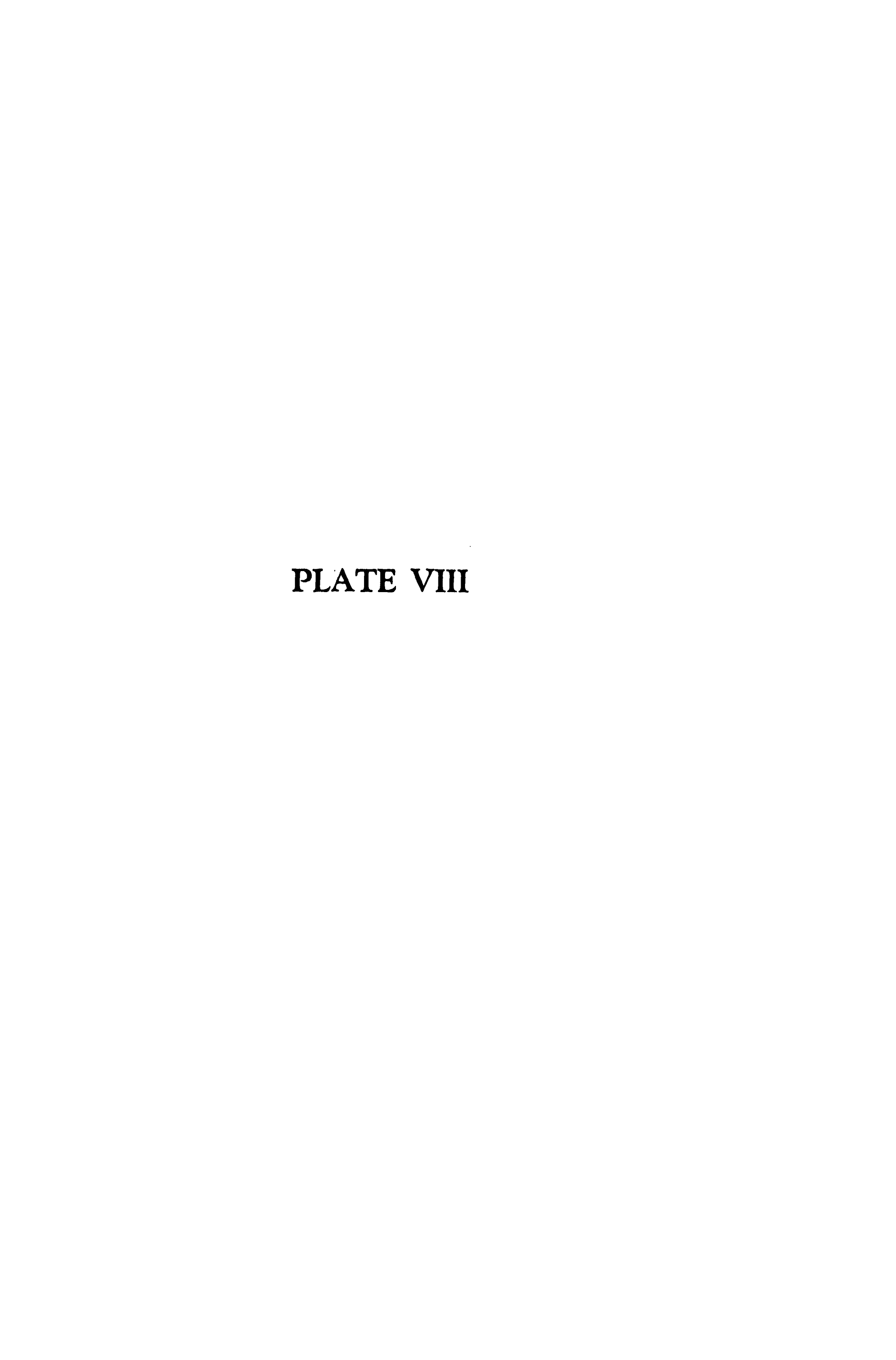


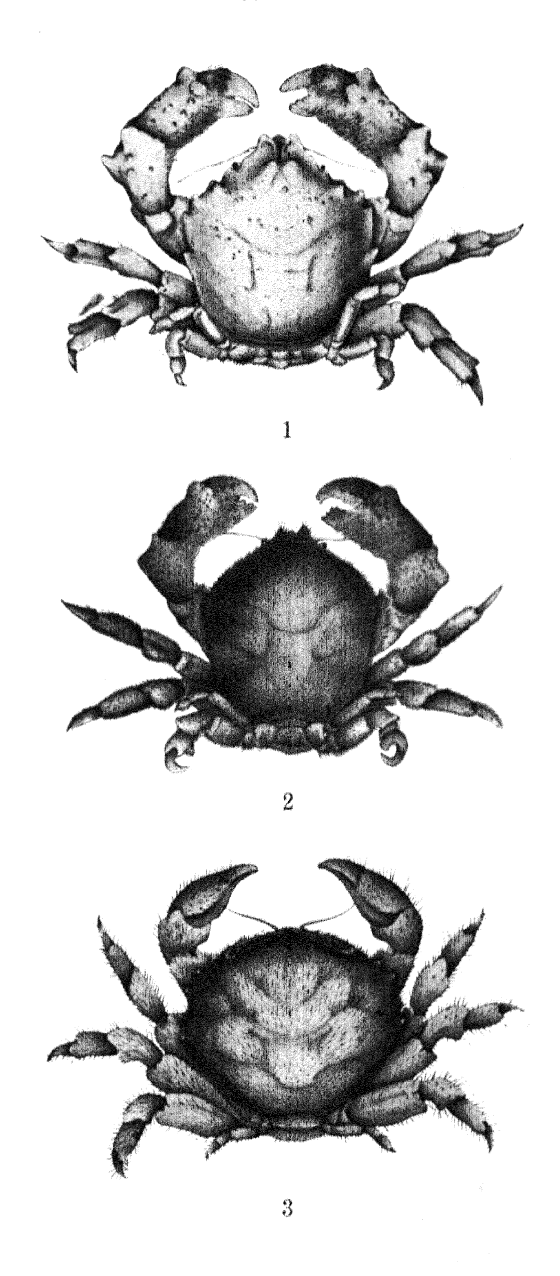
PLATE VIII

Explanation of the Plate VIII

Fig. 1. *Petalomera japonica* (HENDERSON). ♂ from Tokyo Bay, ×1.5.

Fig. 2. *Conchoecetes artificiosus* (FABRICIUS). ♂ from Onomiti M. B. S., ×1.

Fig. 3. *Dynomene hispida* DESMAREST. ♂ from Tosa Bay, ×2.


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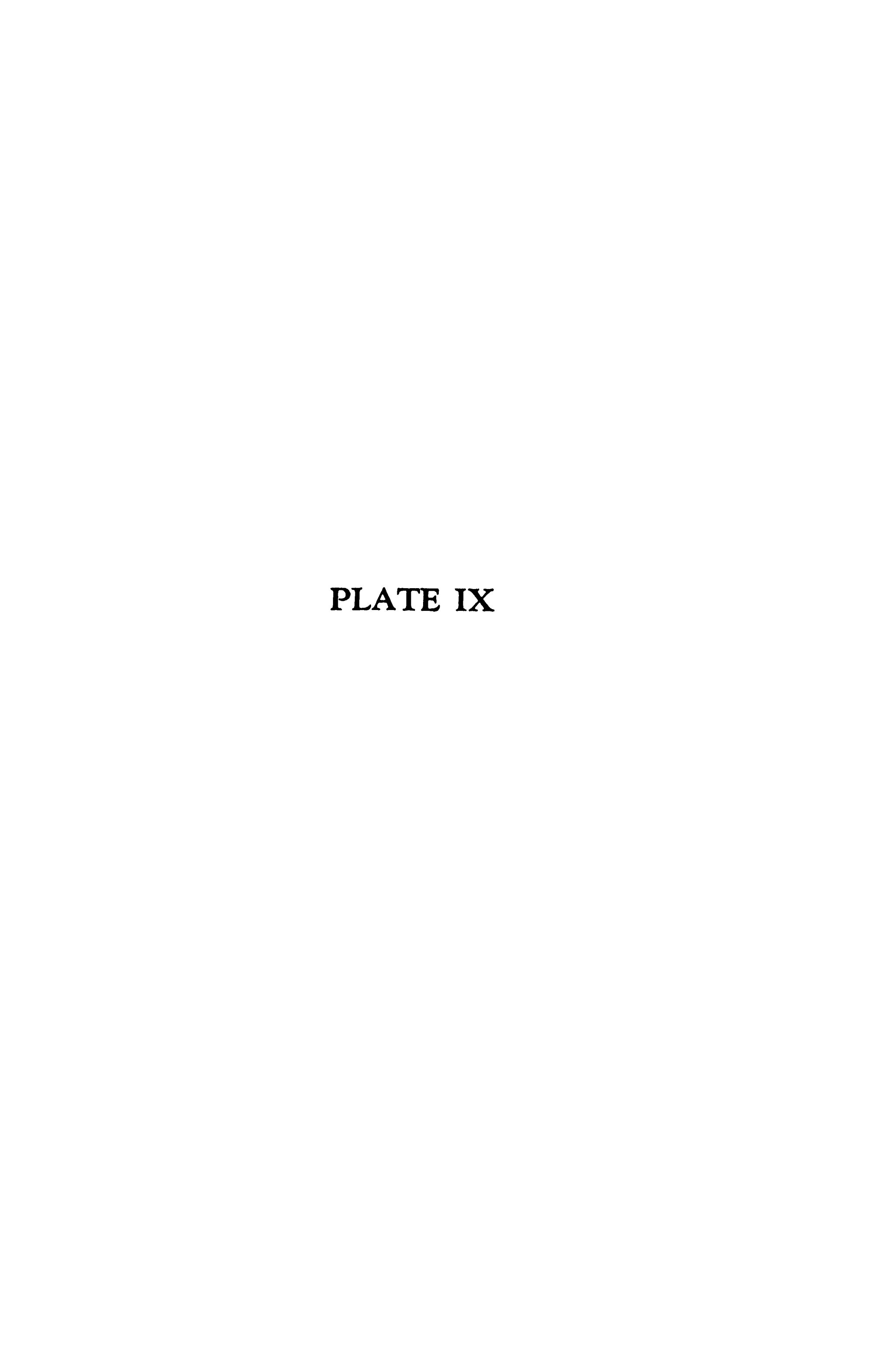
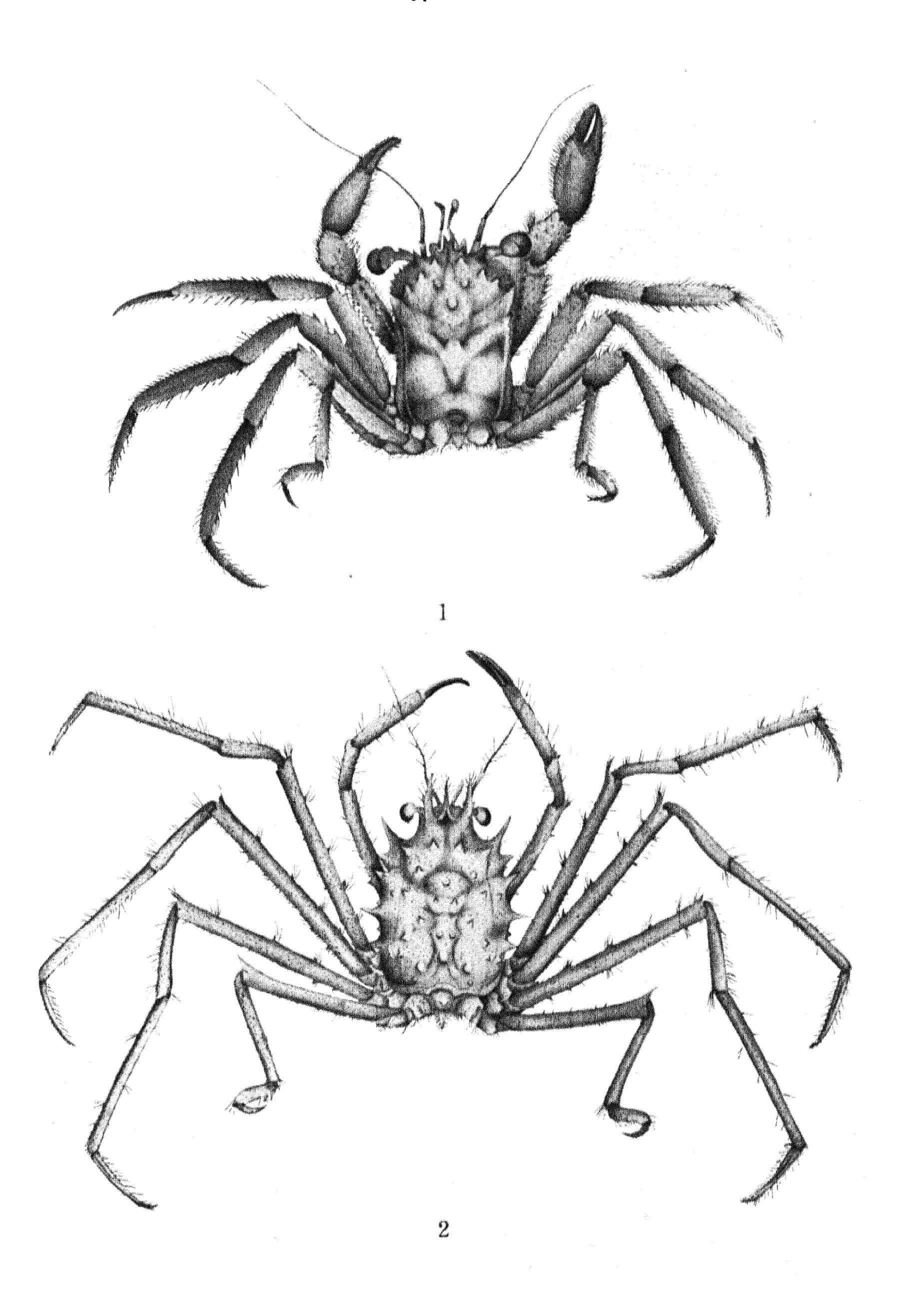


PLATE IX

Explanation of the Plate IX

Fig. 1. *Homola orientalis* HENDERSON. ♂ from Sagami Bay, ×1.2.

Fig. 2. *Homola (Parhomola) majora* (KUBO). ♂ from Aziro, ×4/5.


1
2